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ENGINEER DESIGN TEST 2
HUGHES YAH-64
ADVANCED ATTACK HELICOPTER

FINAL REPORT

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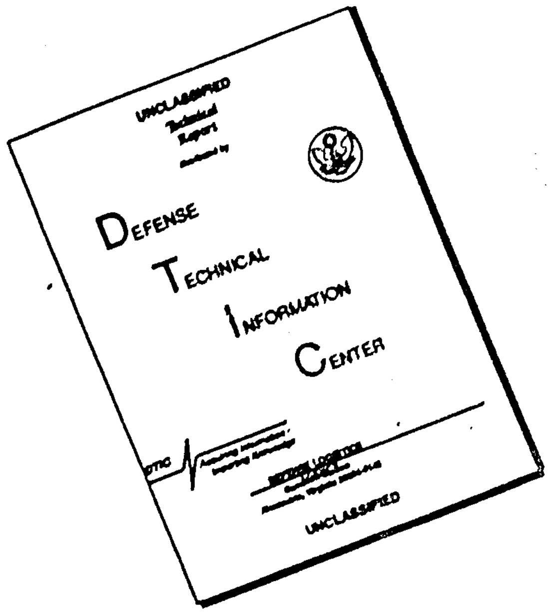

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The United States Army Aviation Engineering Flight Activity conducted a Performance and Handling Qualities Evaluation, Engineering Design Test 2, of the Hughes Helicopter Company YAH-64 advanced attack helicopter from 10 April 1979 through 20 April 1979 at the Hughes Helicopters Flight Test Facility, Palomar Airport, Carlsbad, California (elevation 328 feet). A total of 19 flights were conducted during 20.5 flight test hours (15.6 hours productive). The objectives of the test were to assess the flight characteristics of the aircraft which had incorporated design modifications closer to the final phase 2 airframe configuration;

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update the performance base line and the vibration characteristics derived during Development Test 1 (DT 1). The YAH-64 helicopter continues to possess excellent potential as an attack helicopter, particularly because of its agility. Some enhancing characteristics, deficiencies, and shortcomings previously reported and not specifically addressed in this evaluation remain. Structural limitations imposed by the airworthiness release severely limited this evaluation. In general the performance of the helicopter in terms of power required has deteriorated from DT 1, although there is a slight performance improvement in level flight between approximately 50 and 90 knots true airspeed (KTAS). Tail rotor performance has markedly deteriorated from DT 1. The starting procedure utilized on the YAH-64 helicopter is an enhancing characteristic and should be incorporated in future Army aircraft where possible. There were seven deficiencies (2 previously defined) and 43 shortcomings identified (16 previously defined). The deficiencies include: the possibility of dual-engine fuel starvation with useable fuel remaining; the restricted forward field of view during the landing flare; the inability to control heading with Automatic Stabilization Equipment disengaged at the critical azimuth between 25 to 40 KTAS; insufficient left directional control margin in right sideward accelerations; the lack of adequate cues to warn the pilot of a partial power engine malfunction; low activation threshold of the Low Main Rotor RPM warning; excessive 4/rev lateral vibration (pilot seat) during the termination of the approach and in level flight at airspeeds less than 50 and greater than 130 knots calibrated airspeed (KTAS). Canopy drumming characteristics had improved from Engineer Design Test 1 (EDT 1) but remain a shortcoming.

Hughes YAH-64 Advanced Attack Helicopter

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INTRODUCTION

BACKGROUND

1. In June 1973, the United States Army Aviation Systems Command (AVSCOM) awarded a Phase 1 Advanced Development Contract to Hughes Helicopters (HH). The contract required HH to design, develop, fabricate, and initiate development/qualification of two advanced attack helicopter (AAH) prototypes and a ground test vehicle as part of a Government Competitive Test. The United States Army Aviation Engineering Flight Activity (USAAEFA) conducted Development Test 1 (DT 1) using two of these aircraft. Several deficiencies and shortcomings of the aircraft were found during DT 1 (ref 1, app A). In December 1976, the United States Army Aviation Research and Development Command (AVRADCOM) (formerly AVSCOM) awarded a Phase 2 engineering development contract to HH for further development and qualification of the YAH-64 to include full system, subsystems and qualification of mission essential equipment. USAAEFA conducted Engineer Design Test 1 (EDT 1) with one YAH-64 which had undergone Mod 1 change in April and May 1978. The incorporation of the Mod 1 configuration in the prototype AAH was not intended to correct all aircraft deficiencies and shortcomings identified during DT 1; therefore, many remained during EDT 1 and some new problems were uncovered (ref 2). Deficiencies and shortcomings previously identified may not be fully corrected by Mod 2 configuration changes; however, development status may be assessed as a result of these tests. In March 1979, AVRADCOM directed USAAEFA to conduct Engineer Design Test 2 (EDT 2) of the YAH-64 (ref 3). A test plan (ref 4) was submitted in March 1979, and Airworthiness Releases (refs 5 and 6) were issued in April 1979.

TEST OBJECTIVES

2. The test objectives of EDT 2 were as follows:

a. Assess the flight characteristics of the aircraft which incorporates additional design modifications.

b. Update the performance base line and assess the vibration characteristics from the DT 1 and EDT 1 configurations.

DESCRIPTION

3. The YAH-64 is a two-place tandem-seat, twin-engine helicopter with four-bladed main and antitorque rotors and conventional wheel landing gear. The helicopter is powered by two General Electric YT700-GE-700 turboshaft engines. The YAH-64 incorporates wings with moveable flaps and a T-tail with a fixed horizontal stabilizer mounted above the tail rotor. A 30mm gun can be mounted on a turret assembly on the underside of the fuselage below the forward cockpit. A wooden mockup of the 30mm cannon was used to aerodynamically simulate the gun in the stowed position. The wing pylons can carry HELLFIRE missiles or 2.75-inch folding fin aerial rockets (FFAR). The test aircraft were Army

serial numbers (S/N) 74-22248 and 74-22249. Major changes to the helicopters since EDT 1 include:

a. 6 inch extension of main rotor mast
b. Tip weights added to horizontal stabilizer
c. 4 inch chord extension to upper vertical stabilizer
d. Modified Mod 2 tail rotor
e. Canopy stiffeners

The Martin Marietta PNVS was installed on S/N 74-22248 and the Northrup PNVS was installed on S/N 74-22249. A more detailed description of the aircraft and systems is contained in appendix B.

TEST SCOPE

4. Flight testing for EDT 2 was conducted at Palomar Airport, Carlsbad, California (328-foot elevation) from 10 April 1979 through 20 April 1979. A total of 19 flights were conducted during which 20.5 hours (15.6 hours productive) were flown. Three Army pilots flew the evaluation from the pilot station with an HH pilot acting as the aircraft commander. HH installed, calibrated, and maintained the test instrumentation and performed all aircraft maintenance during the test. Flight restrictions and operating limitations contained in the airworthiness release issued by AVRADCOM were observed during the evaluation. Handling qualities and vibration data were compared to results obtained during DT 1 and EDT 1, where possible. The scope of the test is shown in table 1.

TEST METHODOLOGY

5. Established flight test techniques and data reduction procedures were used (refs 7 and 8, app A). Test methods are briefly discussed in the Results and Discussion section of this report. A vibration rating scale (VRS) (fig. 3, app D) was used to augment crew comments relative to aircraft vibration levels. A handling qualities rating scale (HQRS) (fig. 4) was used to supplement pilot comments on the handling qualities. Flight test data were obtained from calibrated test instrumentation and were recorded on magnetic tape. Real time telemetry was used to monitor selected critical parameters throughout the flight test. A detailed listing of the test instrumentation is contained in appendix C. Data analysis methods are described in appendix D.

Table 1. Test Conditions[1]

Type of Test	Average Gross Weight (lb)	Longitudinal Center-of-Gravity Location[2]	Average Density Altitude (ft)	Trim Calibrated Airspeed (KCAS)
Hover performance[3]	13500 to 17900	Mid	100	Zero
Climb performance	13940 to 14260	Aft	4000 to 7000	72 to 121
Level flight performance[4]	14680 to 14760	Fwd	2300 to 10960	32 to 153[5]
Static longitudinal stability	14520 and 14980	Aft	4760 and 5460	60 and 141
Static lateral directional stability	14780	Aft	5180	59
Maneuvering stability	13800 to 14120	Aft	5160 to 5200	134
Dynamic stability[6]	13680	Aft	5200	89 to 136
Takeoff and landing characteristics	14600 to 15860	Fwd	260 to 420	N/A
Low-speed flight characteristics[6]	14460 to 15860	Fwd and Aft	120 to 560	45 left and right 35 rearward 60 forward[5]

[1] Rotor speed 100 percent unless otherwise noted, vibration data recorded at all conditions tested, clean configuration unless otherwise noted. ASE ON unless otherwise noted.
[2] Longitudinal cg: Fwd: (FS) 200.0 to 202.3; Mid: (FS) 202.4 to 204.7; Aft: (FS) 204.8 to 207.0. All lateral cg's were left (BL) -0.5 to -0.6.
[3] 98 to 100 percent rotor speed (284 to 289 rpm).
[4] 8-Hellfire configuration: One pylon-mounted, Hellfire missile launcher assembly on each inboard wing store station. Each launcher assembly contained four simulated Hellfire missiles.
[5] Knots true airspeed (KTAS).
[6] ASE ON and OFF.

RESULTS AND DISCUSSION

GENERAL

6. The performance and handling qualities characteristics of the YAH-64 were evaluated at the conditions shown in table 1. Some enhancing characteristics, deficiencies, and shortcomings not specifically addressed in this evaluation but discovered during DT 1 and EDT 1, remain. The YAH-64 helicopter continues to possess excellent potential as an attack helicopter, particularly because of its agility. Structural limitations imposed by the airworthiness release (ref 5 and 6, App A) severely limited this evaluation. In general the performance of the helicopter in terms of power required has deteriorated from DT 1, although there is a slight performance improvement in level flight between approximately 50 and 90 knots true airspeed (KTAS). Tail rotor performance has markedly deteriorated from DT 1. The starting procedure utilized on the YAH-64 helicopter is an enhancing characteristic and should be incorporated in future Army aircraft where possible. There were seven deficiencies and 43 shortcomings identified. The deficiencies include: the possibility of a dual-engine fuel starvation with useable fuel remaining; the restricted forward field of view during the landing flare and high power climbs; the inability to control heading with Automatic Stabilization Equipment (ASE) disengaged at the critical azimuth between 25 to 40 KTAS; insufficient left directional control margin in right sideward accelerations; the lack of adequate cues to warn the pilot of a partial power engine malfunction; low activation threshold of the Low Main Rotor RPM warning; excessive 4/rev lateral vibration (pilot seat) during the termination of the approach and in level flight at airspeeds less than 50 and greater than 130 knots calibrated airspeed (KCAS). Canopy drumming characteristics had improved from EDT 1 but remain a shortcoming.

PERFORMANCE

General

7. Performance flight testing of the YAH-64 helicopter was conducted at the HH Flight Test Facility located at Palomar Airport, Carlsbad, California, using aircraft S/N 74-22248 and S/N 74-22249. Aircraft S/N 74-22249 was equipped with specially calibrated engines, but neither aircraft was instrumented to make in-flight measurements of installed engine intake and exhaust losses. Therefore this report only addresses the power required aspects of performance. The hover and level flight performance tests were conducted on aircraft S/N 74-22249 using the results of the test cell engine torquemeter calibration as the basis for power required. The climb and descent tests were conducted on aircraft S/N 74-22248 using the engine acceptance torquemeter calibrations. All forward flight performance tests were flown at zero sideslip. Test conditions are outlined in table 1 and data analysis techniques are contained in appendix D. This performance evaluation included the following tests: tethered hover, forward flight climbs and descents, and level flight performance. All performance measurements were made with the HH Black Hole Ocarina (BHO) infrared suppressor system installed. Performance data presented in this report was not corrected for any parasitic drag caused by the instrumentation installation. The performance of the YAH-64 helicopter as tested in EDT 2 has markedly deteriorated as compared to the same aircraft as tested in the DT 1.

Hover Performance

8. Out of ground effect (OGE) (at a wheel height of 100 feet) hover performance testing was accomplished using the tethered hover technique. A cable angle indicator was used as reference to maintain the cable vertical. A cable tensiometer measured cable tension as power was changed incrementally from power required for minimum cable tension to maximum thrust allowed by the Airworthiness Release. The tests were conducted within a rotor speed range of 98 to 100 percent (284 to 289 RPM). Hover test results are presented in figures 1 and 2, appendix E.

9. The hover power required data (fig. 1) nondimensionalized in terms of thrust and power coefficients does not define a unique line as is common with most helicopters operating where compressibility is not a factor. The YAH-64 DT 1 hover data was a unique line. The EDT 2 data appears as a family of curves along lines of constant rotor speed. The performance significantly decreases as main rotor speed decreases (*i.e.*, opposite of compressibility effects). The non-dimensional tail rotor performance (fig. 2) follows the same trends indicating the performance anomaly is attributable to the tail rotor. At the Army hot day condition (35°C, 4000 feet pressure altitude (H_p)), gross weight of 14240 pounds, and 100 percent main rotor speed the YAH-64 helicopter required 2157 shaft horsepower (SHP) to hover OGE. At the same conditions during the DT 1 evaluation (ref 1, app A), the power required was 2124 SHP. The aircraft required 1.6 percent more power to hover OGE at the above conditions. A contributing factor to this hover degradation was the increase in tail rotor power required (fig. 2, app E). At the same conditions, the tail rotor power required was 19 shaft horsepower (8%) more than during the DT 1 evaluation.

Generalized Forward Flight Climb and Descent Performance

10. The forward flight climb and descent performance of the YAH-64 helicopter was evaluated using the sawtooth climb and descent technique in the clean configuration at an aft longitudinal center of gravity using aircraft S/N 74-22248. Generalized climb and descent performance data are presented in figure 3, appendix E. The power required to achieve a 2000 feet per minute rate of climb (gross weight of 14240 pounds, Army hot day conditions, and at the airspeed for best rate of climb) was 101 SHP (4.6%) less than the same conditions in DT 1. At greater airspeeds, the climb performance has been degraded, compared to that measured during DT 1.

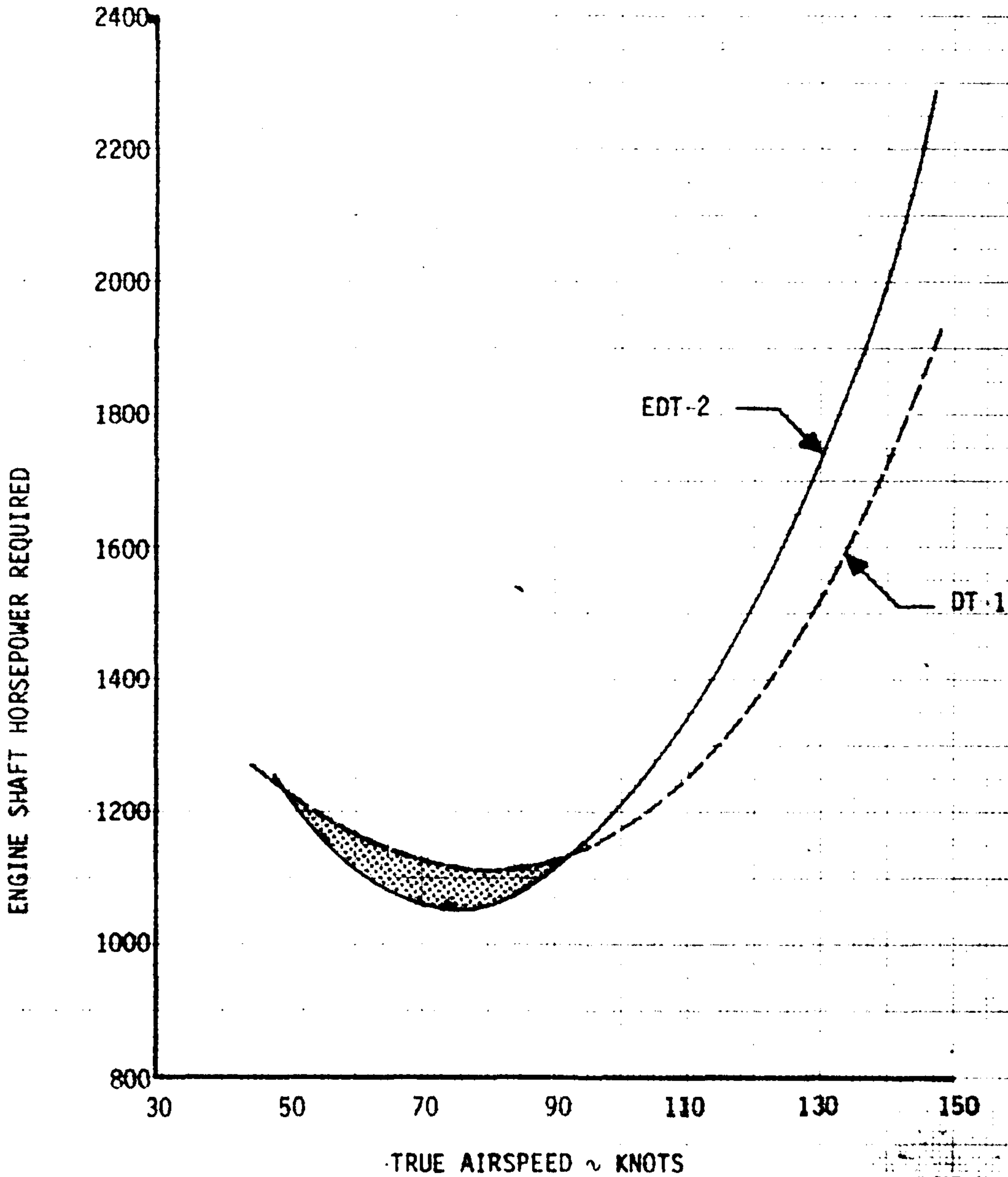
Level Flight Performance

11. Level flight performance tests of the YAH-64 helicopter, in the 8-HELLFIRE configuration, were conducted to determine power required as a function of airspeed. Data were obtained in zero sideslip stabilized level flight at a forward longitudinal center of gravity. A constant thrust coefficient was maintained by increasing altitude as fuel was consumed. Non-dimensional level flight performance is presented in figures 4 through 6, appendix E, and the results of the level flight performance tests are presented in figures 7 through 10. A comparison of the power required for Army hot day conditions, from the DT 1 and EDT 2 evaluations, at 14240 pounds is shown in figure A. At 140 KTAS the power required increased 276 SHP which equates to an equivalent flat plate area increase of 12 square feet (propulsion efficiency equal to unity). At airspeeds between 49 and 92 KTAS, the power required shows slight improvement indicating a possible improvement in

FIGURE A
LEVEL FLIGHT PERFORMANCE COMPARISON
YAH-64 USA S/N 74-22249

GROSS WEIGHT (LB)	LONG. CG LOCATION	PRESSURE ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	C_T
14240	FWD	4000	35	289	0.00777

NOTES 1. CONFIGURATION
A. EDT-2 8 HELLFIRE
B. DT 1 8 TOW
2. SHADED AREA DENOTES IMPROVED PERFORMANCE



LEVEL FLIGHT PERFORMANCE COMPARISON FOR EDT 2 AND DT 1

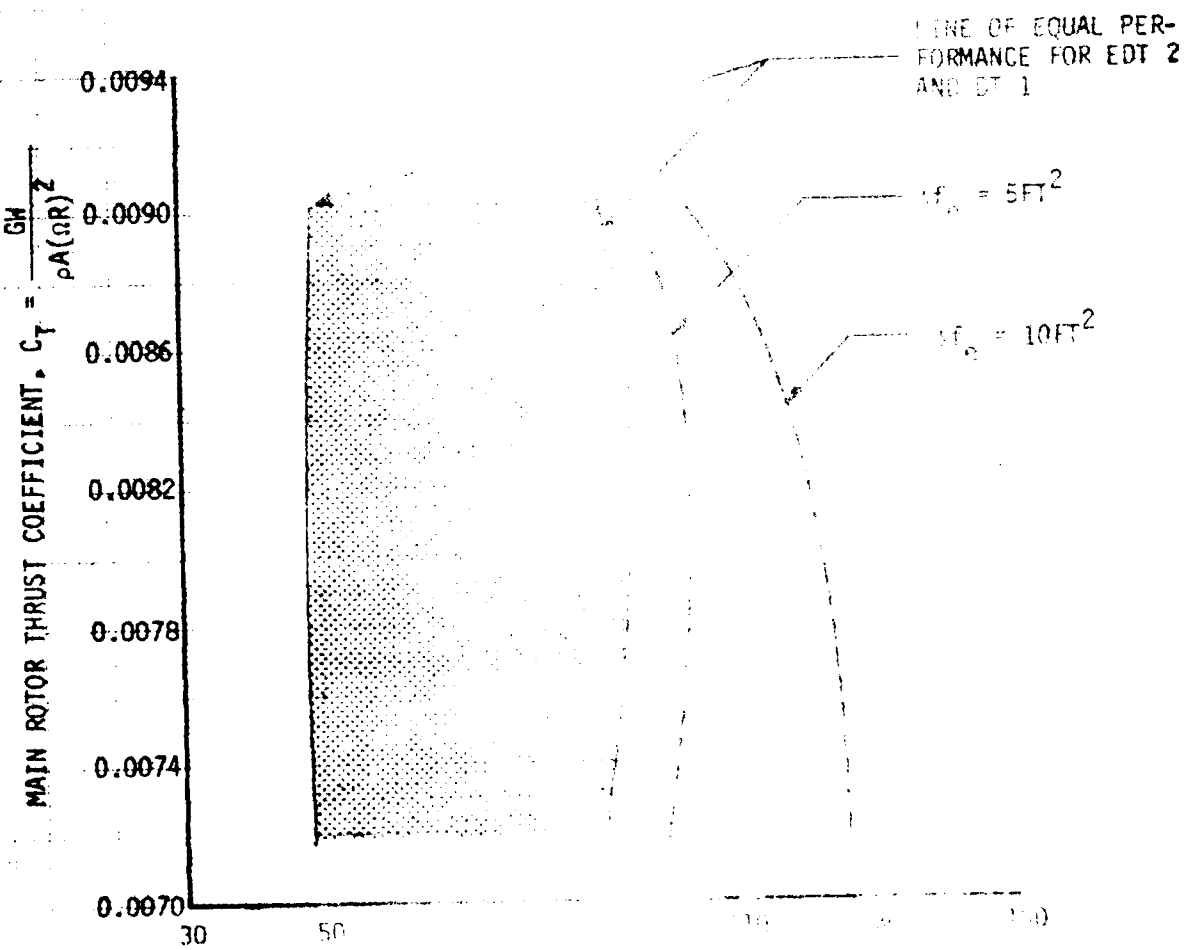
N 74-22249

NOTE: SHADED AREA DENOTES IMPROVED PERFORMANCE

CONFIGURATION

EDT 2 — 8 HELLFIRE

8 TOW



endurance and loiter capability. DT I was conducted in the 8-TOW configuration whereas EDT 2 was conducted in the 8-HELLFIRE configuration.

12. The change in level flight performance of the YAH-64 from DT I to EDT 2 varied with C_T and airspeed. Figure B summarizes this variation. For airspeed and C_T combinations within the shaded area, performance was slightly improved. For airspeed and C_T values to the right of the shaded area, the helicopter performance has been markedly degraded as shown by lines of increasing equivalent flat plate area. No DT I data was available between hover and 40 KCAS, but hover data (para 9) indicated that the YAH-64's performance has degraded since DT I at all C_T values evaluated.

HANDLING QUALITIES

General

13. The handling qualities characteristics were evaluated at the test conditions listed in table 1. The handling qualities evaluation utilized standard flight test maneuvers. All maneuvers were flown at zero sideslip where possible. An HQRS rating scale was used to quantify the degree of pilot workload required to perform specific tasks.

Control System Characteristics

14. The control system mechanical characteristics of the YAH-64 were measured on the ground utilizing ground electrical and hydraulic power, and qualitatively reevaluated in flight. Figures 11 through 18, appendix E, are results of tests performed. Tables 2 and 3 are a summary of mechanical characteristics for both helicopters.

15. The longitudinal and lateral cyclic mechanical characteristics exhibited excessive breakout (plus friction) forces, weak control force gradients, and weak or no positive control centering. It was possible to displace the cyclic laterally without retrimming, release the cyclic, and have it remain at that position. This condition causes an increased pilot workload especially during simulated instrument meteorological condition (IMC) flight. Low force gradients are desirable in nap of the earth (NOE) flight, however excessively low force gradients could lead to pilot induced oscillations. The excessive breakout (plus friction) forces, weak control force gradients, and weak control centering of the longitudinal and lateral cyclic control are shortcomings.

16. When retrimming the helicopter, the directional control exhibited undesirable jump. This was noted at all flight conditions. The control jump would result in unwanted yaw excursions during retrimming, which would be disconcerting to the pilot. The excessive directional control jump is a shortcoming previously reported.

Control Positions in Trimmed Forward Flight

17. The control positions in trimmed forward level flight were evaluated from 31 to 150 KCAS at various altitudes noted in table 1. The data were obtained in conjunction with level flight performance (fig. 19 through 22). The pitch attitude of the helicopter varied from 5 degrees nose up at 31 KCAS to 3 degrees nose down at

Table 2. Control System Mechanical Characteristics (S/N 74-22248)

Test Parameter	Control system: Longitudinal	Control system: Lateral	Control system: Directional
Breakout force (plus friction) (lb)	2.4 fwd, 2.0 aft	1.6 left, 1.5 right	4.5 left, 6.0 right
Full control travel (in.)	10.19	9.60	5.43
Control oscillation	None	None	None
Free play (in.)	Negligible	Negligible	Negligible
Mechanical coupling	None	None	None
Force to move stick 0.5 inch from trim (lb)	3.0 fwd, 2.6 aft	1.9 left, 1.7 right	N/A
Limit control force (lb)	9.5 fwd, 8.5 aft	3.8 left, 4.0 right	23.5 left, 23 right
Control centering	Weak	None	Positive
Control jump	Negligible	Negligible	Significant
Control forces trimmable to zero	Yes	Yes	Yes
Force gradient (lb/in.)	0.85 fwd, 1.2 aft	0.42 left, 0.12 right	2.5 left, 2.18 right

Table 3. Control System Mechanical Characteristics (S/N 74-22249)

Test Parameter	Control System		
	Longitudinal	Lateral	Directional
Breakout force (plus friction) (lb)	2.2 fwd, 1.4 aft	0.7 left, 1.8 right	9.5 left, 9.0 right
Full control travel (in.)	9.72	9.42	5.38
Control oscillation	None	None	None
Free play (in.)	Negligible	Negligible	Negligible
Mechanical coupling	None	None	None
Force to move stick 0.5 inch from trim (lb)	2.6 fwd, 1.8 aft	1.4 left, 2.5 right	N/A
Limit control force (lb)	6.0 fwd, 5.0 aft	4.5 left, 5.0 right	22.5 left, 30 right
Control centering	Weak	None	Positive
Control jump	Negligible	Negligible	Significant
Control forces trimmable to zero	Yes	Yes	Yes
Force gradient (lb/in.)	0.67 fwd, 0.51 aft	0.30 left, 0.50 right	1.8 left, 2.0 right

150 KCAS. The aircraft exhibited a varying and undesirable control position gradient (increasing aft cyclic with increasing airspeed) from 60 KCAS to 100 KCAS, which made stabilizing at an altitude and airspeed in this speed range difficult (HQRS 5). It was possible to trim at one airspeed, disturb the aircraft, and have it restabilize at another airspeed without changing the cyclic position. The *nonlinear trim requirement, making precise airspeed and attitude control difficult between 60 and 100 KCAS, is a shortcoming previously reported.*

18. Throughout the flight envelope, the aircraft exhibited a random yaw "shuffle" which was characterized by yaw oscillations of ±2 degrees. The shuffle occurred most frequently in the 50 to 80 KCAS range in level flight with tail oscillation observed by the chase pilot. This condition could become a problem when using a point-fire weapon in forward flight by randomly moving the aiming point above the target. The random yaw "shuffle" is a shortcoming.

19. The trimmed control positions in forward flight climbs and autorotations were evaluated at conditions shown in table 1. At a stabilized speed intermediate rated power (IRP) was applied for climbs and minimum power (zero to 5 percent torque) for descents (fig. 23, app E). The nose-high attitude of 11 degrees at 70 KCAS reduced the forward field of view markedly during high power climbs. The pilot had to continually "S" turn the helicopter in order to clear himself of other aircraft. The restricted field of view due to the nose-high attitude during IRP climbs is a shortcoming previously reported.

20. The difference in longitudinal control positions between IRP climbs and minimum power descents over the airspeed range tested varied from 2.3 to 3.2 inches. *The longitudinal control position change with change in collective position is significant.* At 105 KCAS a 3-inch change in collective position would require a 1 inch change in longitudinal cyclic in order to maintain airspeed. In the NOE environment, the pilot would have to continually retrim the longitudinal cyclic due to frequent power changes. The excessive longitudinal cyclic position change with power application is a shortcoming previously reported.

Static Longitudinal Stability

21. The static longitudinal stability characteristics of the helicopter were evaluated at the conditions noted in table 1. The helicopter was trimmed in level flight at zero sideslip with the collective control fixed. The helicopter was then stabilized at incremental airspeeds greater and less than the trim airspeed. The data from these tests is presented in figures 24 and 25, appendix E. The longitudinal cyclic position gradient at both airspeeds tested was approximately neutral. The pilot can achieve a 40-knot difference in airspeed with virtually the same longitudinal control position. In maneuvers such as a diving gun run the lack of positive static longitudinal stability may be advantageous, however, the pilot could expect to work harder doing a high-gain task such as a precise airspeed control during IMC. The longitudinal static stability characteristics are adequate.

Static Lateral-Directional Stability

22. The static lateral-directional stability characteristics of the helicopter were evaluated at the conditions shown in table 1. The helicopter was stabilized in trim level flight at zero sideslip. The collective was fixed and sideslip angles (left and right) were induced in 5 degree increments to 30 degrees while maintaining constant

airspeed and ground track and allowing altitude to vary. The data were recorded at each stabilized point (fig. 26, app E). At 59 KCAS the helicopter exhibited positive directional stability (right sideslip with increasing left directional control), a positive dihedral effect (right sideslip with right lateral control position), and positive but weak sideforce characteristics (right roll attitude with right sideslip). The roll attitude varied only 5 degrees about the trim point, which would be desirable during NOE maneuvering or attempting to get within missile launch constraints. At 59 KCAS, the static lateral-directional stability characteristics of the helicopter are adequate.

Maneuvering Stability

23. The maneuvering stability characteristics were evaluated using constant airspeed left- and right-hand turns and pushovers and pull ups at the flight conditions listed in table 1. The force feel system (FFS) was inoperative during the evaluation. Maneuvering stability characteristics are presented in figures 27 and 28, appendix E. Vibration levels increased noticeably with increasing normal acceleration and are discussed in paragraph 54.

24. Figure 27, appendix E, shows the stick-fixed (control position vs g) and the stick-free (control force vs g) maneuvering stability of the YAH-64 during fixed collective, zero sideslip turning flight at 134 KCAS. The stick-fixed maneuvering stability was positive and essentially linear with a gradient of approximately 0.3 in/g. The stick-free maneuvering stability was weakly positive (approximately 1.2 lb/g) and the control forces were qualitatively judged to be light. Shallow stick free maneuvering stability gradient is a shortcoming. Roll attitude could be adequately obtained up to the maximum roll attitude tested (60 degrees). At bank angles of 40 degrees or greater, random uncommanded yaw excursions were observed which made precise airspeed control more difficult. Random uncommanded yaw excursions in steady state banks of 40 degrees or greater is a shortcoming.

25. Stick-fixed maneuvering stability was evaluated using symmetrical pull ups and pushovers. Data are presented in figure 28, appendix E. Stick-fixed maneuvering stability gradient was positive at the airspeed tested (134 KCAS). The gradient was approximately 0.6 in/g. The aircraft was fully controllable at the lowest g level tested (0.2 g). At low g levels, the oil pressure accessory pump caution light often illuminated, as it did during low speed sideward flight (para 75), but extinguished quickly after reestablishing a 1.0g flight condition. The problems with the oil pressure sensor were also observed during the DT I and during EDT I, and are discussed in those reports. No divergent pitch tendencies were noted. However, the weak stick free maneuvering stability resulted in the pilot consistently overshooting his target load factor during symmetrical pullups. The maneuvering stability characteristics of the YAH-64 remain essentially unchanged from those observed during the DT 1 and EDT 1.

Dynamic Stability

26. The short-term dynamic stability characteristics (gust response) of the YAH-64 were evaluated at the conditions listed in table 1. Aircraft motions were induced by one inch lateral doublets, ASE ON and OFF, attitude hold OFF. Following the input, all controls were held fixed until the aircraft motion subsided or until a limit was approached. The short-term dynamic response characteristics were also evaluated by disengaging the ASE at 136 KCAS, and observing the resulting aircraft motions. Dynamic stability tests were discontinued after 2 oscillations at 136 KCAS

due to sideslip limits. Typical time histories are presented in figures 29 and 30, appendix E, and the damping summary is presented in figure 31. The ASE ON dynamic stability characteristics were essentially deadbeat and are satisfactory.

27. The response of the YAH-64 to ASE OFF lateral doublets was a pitch-coupled dutch roll oscillation. This mode coupled all three axes and was essentially identical to the oscillation observed during EDT 1. ASE OFF one inch lateral doublets were made at approximately 10 knot increments between 89 and 136 KCAS. Figures 29 and 30 are typical examples of this oscillatory response. The damping of the oscillation decreased with increasing airspeed. At 89 KCAS the oscillation was noticeable but well damped. The oscillation became neutrally damped at approximately 110 KCAS. Above 110 KCAS, oscillations became increasingly divergent. The period of oscillation was approximately four seconds. The oscillations were easily controlled by the pilot. The ASE OFF pitch-coupled dutch roll damping was slightly degraded from that observed during EDT 1 (neutrally damped at 110 KCAS versus 117 KCAS). The ASE OFF pitch-coupled dutch roll remains a shortcoming.

Ground Handling Characteristics

28. Ground handling characteristics were evaluated on a daily basis (ASE ON and OFF) on concrete and macadam taxiways. Wind conditions were generally less than 10 knots except for occasional gusts to 15 knots.

29. Ground handling characteristics remained essentially unchanged from those noted in previous evaluations. During the evaluation, the yaw ASE authority was set at 20 percent and the yaw Command Augmentation System (CAS) was automatically disengaged by a touchdown relay (squat switch) located on the left main landing gear. The automatic disengagement of the yaw CAS is a feature incorporated since EDT 1 and eliminated the shortcoming identified in EDT 1 which required the pilot to desengage the ASE for ground operations. When taxiing with the yaw ASE ON, it may be possible for the tail of the aircraft to inadvertently slew in the directional axis with a malfunction in the yaw ASE (actuator hardover) which may result in aircraft damage. If the tail wheel is aligned laterally during a yaw ASE hardover, the possibility of aircraft damage will be further increased. An evaluation should be performed to determine the effects of yaw ASE hardovers during ground taxi operations (to include running landings).

30. As previously reported, the YAH-64 requires excessive brake pedal pressure, which resulted in inadvertent directional inputs while attempting to brake during ground taxi operations. The pilots were unable to brake unless the pilot's heels were placed higher than normal on the directional pedals. The inadvertent directional inputs by the pilot, due to the excessive pedal pressure required during braking, are a shortcoming.

Takeoff and Landing Characteristics

31. Takeoffs were evaluated during each flight. Maximum performance, normal, and minimum power takeoffs were evaluated at different weighings and cg positions. Figure 32, appendix E, is a time history of a normal takeoff. At a hover, the longitudinal cyclic position was 6.4 inches from the forward stop. At 70 knots indicated airspeed (KIAS), the longitudinal cyclic position was 4.4 inches from the forward stop. This large longitudinal control displacement was objectionable during takeoff, however, it would be more so during NOE maneuvering because of the need to constantly retrim as airspeed changes. The large longitudinal control displacement during takeoffs is a shortcoming previously reported.

32. Landings of the helicopter were evaluated during each flight. Normal, low level, steep, and autorotative (minimum power) landings were performed at different weights and cg locations. Descent and approach airspeeds were varied throughout the test. The field of view during landing was very poor. The steeper the glide path, the longer the point of intended landing remained out of view. At higher airspeeds (90 KIAS or above) the field of view was improved until the landing flare, at which time the point of intended landing was obscured until the helicopter came to a hover. Figure 33, appendix E, is a time history of a steep approach. During a steep approach, the pitch attitude of the aircraft changed from one degree nose up at 95 KIAS to 20 degrees nose up at 55 KIAS. In the NOE environment, the poor field of view due to the nose-high attitude during quick stops would make it extremely difficult for the pilot to see obstacles in his path. The pilot's restricted forward field of view due to the excessive nose-high attitude during the landing approach is a deficiency.

33. A 20 degree nose-high attitude during the landing flare puts the tail wheel of the helicopter approximately eight feet below the main landing gear. This increases the probability of tail rotor damage. An NOE evaluation should be performed to determine the ramification of restricted field of view and aircraft attitudes on the NOE mission accomplishment.

Low-Speed Flight Characteristics

34. The low-speed flight characteristics of the YAH-64 were evaluated at the conditions listed in table 1. A ground pace vehicle was used as a speed reference during all low-speed flight evaluations. Surface wind conditions were four knots or less. Tests were conducted at a main wheel height of approximately 15 feet (IGE). Test data are presented in figures 34 through 44, appendix E.

Sideward Flight

35. In all conditions tested, the increasing right lateral cyclic control position with increasing right sideward velocity, up to 35 KTAS, indicates a nonlinear but normal (increasing right lateral control with increasing airspeed) gradient (figs. 34 through 37). At 40 to 45 KTAS, there was a lateral control reversal (ASE ON); however, it was not objectionable. With a forward cg (FS ~200) in right sideward flight at 45 KTAS, full left directional control was required. At the same condition at an aft cg (FS ~205) approximately 0.5 inches of left directional control remained. When comparing directional control positions with those obtained in EDT 1 under similar conditions it was noted that there was a degradation in tail rotor performance. In almost all sideward flight conditions during EDT 2 an additional one inch of left directional control was required over that of EDT 1. A comparison of required tail rotor shaft horsepower between EDT 1 and EDT 2 was also made. It was noted that at 45 KTAS (right sideward flight) the required tail rotor shaft horsepower had increased significantly (~39 percent at forward cg and ASE ON). Additional low-speed testing should be accomplished at higher density altitudes.

36. Figures 36 and 37 present the trim curves of the YAH-64 in ASE OFF left and right sideward flight. Control position trends are in close agreement with figures 34 and 35 (ASE ON trim curves); however, there is a marked increase in longitudinal, lateral and directional control activity in left sideward flight at airspeeds in excess of 15 KTAS. At airspeeds between 25 and 40 KTAS with forward cg, the pilot could only maintain heading within ±6 degrees with directional

control excursions greater than 3 inches and had considerable difficulty stabilizing on airspeed (HQRS 8). The left sideward flight characteristics are considered to be deficient with ASE OFF since the system is such that a single failure of the primary hydraulic system results in a loss of all ASE functions. The inability to control heading, ASE OFF, in left sideward flight at 25 to 40 KTAS is a deficiency.

37. A critical azimuth determination flight (forward cg) was made, and the critical azimuth was found to be between 240 to 260 degrees aircraft azimuth (fig. 38) which was unchanged from EDT 1. An evaluation at a critical azimuth of 250 degrees was then performed ASE ON and OFF, figures 39 through 42. The aircraft could be flown at this azimuth, ASE ON; however, considerable pilot compensation was required at airspeeds greater than 20 KTAS (HQRS 5). Figure 38 shows that the yaw ASE was saturated at these flight conditions. With ASE OFF at airspeeds greater than 15 KTAS, the aircraft could not be stabilized at the critical azimuth (HQRS 9). The inability to control heading, ASE OFF, in sideward flight at the critical azimuth from 15 to 35 KTAS remains a deficiency. The YAH-64's handling qualities in sideward flight (airspeeds greater than 20 KTAS) at the critical azimuth, ASE ON, remain a shortcoming.

Forward and Rearward Flight

38. Figures 43 and 44 depict the control positions and pitch attitude of the YAH-64 with ASE ON and OFF in low-speed forward and rearward flight. With ASE ON, a longitudinal control reversal, although not objectionable, was present at forward airspeeds between 25 and 35 KTAS and at rearward airspeeds greater than 25 KTAS. The low-speed forward and rearward flight handling qualities of the YAH-64 remain satisfactory.

Power Management

39. Power management characteristics of the YAH-64 were evaluated throughout EDT 2. The torque matching and turbine gas temperature (TGT) limiting features of the YT 700-GE-700 engines were excellent.

40. During the evaluation, the low rpm rotor warning would not activate until main rotor rpm dropped below approximately 91 percent. This activation threshold would be unsatisfactory in providing a warning of a low main rotor rpm condition. The low activation threshold of the low rpm rotor warning is a deficiency.

41. In the configuration tested, the YAH-64 had a pilot adjustable friction on the engine control panel, designed to allow friction variation on the engine power levers. During the evaluation, it was found that the inherent friction level in the engine power lever assembly was excessive (adjustable friction full OFF). Precise engine power lever movement (as would be required during electrical control unit lockout operation) was difficult. Due to the high inherent friction level, the purpose of an adjustable friction was negated. The high inherent friction in the engine power levers assembly is a shortcoming.

Mission Maneuvering Characteristics

42. Left and right lateral accelerations were conducted under the conditions listed in table 1. Engine torque was incrementally increased on successive accelerations until maximum allowable power was reached. Aircraft response to lateral cyclic control was quick and positive, allowing rapid attainment and excellent control of roll attitude during the maneuver. During all left lateral accelerations the pilot was

able to maintain heading control. However, during the moderate right lateral accelerations the directional control margin was minimal (less than 1.0 percent). When a maximum right lateral acceleration was attempted, the left directional control limit was reached at approximately 25 KTAS and aircraft heading could not be maintained (HQRS 10). Additionally, a further degradation in tail rotor performance can be expected as the density altitude is increased. The insufficient left directional control in right lateral accelerations is a deficiency.

Instrument Flight Capability

43. Instrument flight characteristics were evaluated throughout the test. However, two specific flights were conducted to simulate IMC. During one of these flights, the pilot wore a removeable "hood" to restrict his peripheral vision. Both flights were conducted in light turbulence. Navigational equipment installed limited the evaluation to basic instrument pilot tasks, i.e., climbs and descents, standard rate turns, level flight, airspeed changes, instrument takeoffs (ITO), and simulated ground controlled approaches.

44. When accelerating from a hover to 70 KIAS during ITOs, the aircraft exhibited excessive pitch attitude changes (nose-up) which required large longitudinal cyclic control inputs (approximately three inches) to maintain a correct pitch attitude. The large trim change required during acceleration decreased flight path accuracy and increased pilot workload (HQRS 5). This was previously discussed in paragraph 31.

45. At airspeeds between 60 and 90 KIAS the longitudinal control displacements resulting from power applications increased the pilot workload significantly in simulated IMC flight. This shortcoming is discussed in detail in paragraph 20.

46. At airspeeds greater than 120 KIAS (attitude hold ON) the pilot workload in obtaining and maintaining a precise airspeed was significantly increased. With attitude hold OFF the pilot workload was further increased. The increase in pilot workload (attitude hold ON) when attempting to obtain and maintain precise airspeed greater than 120 KIAS is a shortcoming. Simulated IMC flight in moderate or greater turbulence should be evaluated prior to final judgment of IMC flight characteristics.

Aircraft Systems Failures

Simulated Engine Failures:

47. To warn the pilot of engine malfunctions the YAH-64 utilized warning lights and aural warning devices for gas producer speed (N_G), power turbine speed (N_P), and main rotor speed (N_R). Due to the various activation thresholds of the warning devices, the pilot will have no warning, other than the primary engine instruments, of a partial power engine malfunction if the failure stabilizes at an N_G greater than 63 percent. This failure in a low power flight configuration such as a steep approach or quick stop will be very difficult to detect since the torque split will be small. Additionally, in the NOE environment the pilot will not be able to maintain an adequate cross-check of the primary engine instruments. Therefore, it is imperative that the pilot be given warning of partial power engine malfunctions. The lack of adequate cues to warn the pilot of a partial power engine malfunction is a deficiency.

Automatic Flight Control System Failures:

48. Simulated total ASE failures (disengagements) were qualitatively evaluated during the simulated IMC evaluations. Basic maneuvers were performed ASE OFF with minimal pilot effort (HQRS 3). Above 120 KCAS, ASE OFF, the pilot workload in controlling the pitch coupled dutch roll increased significantly (HQRS 6). The ASE OFF handling qualities of the YAH-64 below 120 KCAS during simulated IMC are satisfactory.

STRUCTURAL DYNAMICS

Vibration Characteristics

49. Vibration characteristics of the YAH-64 were qualitatively evaluated throughout the test program and quantitatively evaluated at the conditions listed in table 1. Vibration characteristics are shown in figures 45 through 107, appendix E.

50. The 4/rev (19.2 Hz) lateral vibrations were objectional to the pilots. Figures 46 and 55 depict the lateral vibration characteristics for both aircraft measured at the pilot seat during airspeed sweeps. Generally vibrations levels of S/N 74-22248 were quantitatively and qualitatively evaluated to be slightly higher than S/N 74-22249. The moderate 4/rev lateral vibrations at airspeeds from 50 to 70 KCAS, and 100 to 130 KCAS were very noticeable to the pilot (VRS 4), but did not appear to increase the pilot workload significantly. However, at airspeeds less than 50 KCAS and greater than 130 KCAS the magnitudes of the lateral 4/rev vibration increased significantly. The vibratory accelerations reached 0.7g at 34 KCAS (VRS 7) and 0.5g at 146 KCAS. The highest lateral 4/rev vibratory acceleration was experienced during final approach while decelerating through translational lift (approximately 15 knots). At this point the pilot experienced 0.8g which blurred cockpit instruments and caused cyclic stick vibrations (VRS 8). The excessive 4/rev lateral vibration (pilot seat) during the termination of approach and in level flight at airspeeds less than 50 KCAS and greater than 130 KCAS is a deficiency.

51. At rearward airspeeds greater than 15 KTAS the vertical and lateral 4/rev vibrations increased significantly figures 81 and 82. However, the increase was much less at the copilot-gunner seat, figures 84 and 85. The 4/rev vertical vibration reached a maximum of 0.2g (fig. 81) at 25 KTAS (VRS 4).

52. Figures 72 through 80, depict the vibration levels of the YAH-64 in sideward flight. At right sideward airspeeds greater than 15 KTAS, the 4/rev vibrations measured at the aircraft's cg and pilot seat increased significantly. The lateral vibration level peaked at 30 KTAS and reached 0.5g at the pilot's seat (VRS 6). As in rearward flight, the increase in vibrations measured at the copilot-gunner's seat was less than that measured at other stations.

53. The vibration characteristics of the YAH-64 were also evaluated in climbs and descents and the results are presented in figures 63 through 71. At airspeeds from 108 to 118 KCAS in high-powered climbs, the lateral 4/rev accelerations measured at the pilot seat were excessive (VRS 5). It should be noted that the trends indicated that the lateral vibrations increase with airspeed; however, 118 KCAS was the maximum airspeed evaluated in climbs. The moderate vibration in right sideward, rearward flight, and in high power climbs (108 to 118 KCAS) is a shortcoming.

54. Figures 90 through 98, depict the vibration levels of the YAH-64 in maneuvering flight. Vibration increases with increasing normal acceleration were noticeable as an increase in 4/rev airframe vibration levels (VRS 5). No perceptible instrument blurring or control vibrations were noted.

Structural Loads

55. During contractor developmental testing, high structural loads observed in the tail rotor, empennage, and tail boom were critical in certain flight regimes, so that continual telemetry monitoring was required. Consequently, the flight envelope of the YAH-64 was limited by the airworthiness release (refs 5 and 6, app A). The evaluation was severely limited by the high structural loads, monitored by telemetry, in sideward flight including lateral accelerations, and the very low sideslip envelope at high speed.

HUMAN FACTORS

Cockpit Evaluation

56. The cockpit layout, switch function design and position, instrument position, available cues, storage, and procedures were evaluated throughout flight testing and training. The simple, straight forward, and effective starting procedure used in the YAH-64 is an enhancing characteristic. Consideration should be given to incorporating this type of procedure in future Army aircraft.

57. The pilot must use his thumb on the cyclic grip to perform eight different functions. Some of these functions are required to be performed simultaneously such as keying the microphone and trimming the aircraft. Additionally, the extreme reach for the trim release button is tiring to the pilot with a smaller than normal hand. The poor anthropometric design of the cyclic grip is a shortcoming.

58. In order to use the emergency canopy jettison handle, the pilot must use his left hand, squeeze the handle symmetrically and pull. If a pilot's left arm or hand is injured, jettisoning the canopy would become extremely difficult, if not impossible. The poor anthropometric design and location of the canopy jettison handle is a shortcoming, previously reported.

59. When the engine condition levers (ECL) are in full aft position, the engine fuel switches are difficult to see. These switches control the firewall fuel shutoff valves. In the event of an emergency, the pilot would be unable to see the fuel switches with the ECL's in the aft position, but would have to verify OFF by touch. The poor location of engine fuel switches is a shortcoming previously reported.

60. The parking brake handle position is the only cockpit indication of whether the brakes are set or released. During ground operations, the brakes on occasion were found to be set even with the parking brake handle full in (OFF position). Inadequate cockpit cues to determine parking brake status is a shortcoming.

61. When locking or unlocking the tail wheel, the pilot had difficulty seeing the tail wheel lock/unlock light. Because of its position, the light was blocked by the glare shield, and the pilot had to bend over to see it. The poor location of the tail wheel lock/unlock light is a shortcoming.

62. The present pilot seat of the YAH-64 is adjustable only in the vertical axis. The tilt mechanism used in EDT 1 was locked out to reduce vibrations felt by the pilot. For those individuals at the extreme range of Army anthropometric measurements, the inability to longitudinally adjust the seat would present a problem. Although the directional pedals are adjustable, the cyclic and collective controls are not. Therefore a small or large person must modify his posture to manipulate the controls which would induce fatigue. The lack of a longitudinal seat adjustment on the YAH-64 is a shortcoming previously reported.

63. The directional pedal adjustment on the YAH-64 was provided by turning a rotary knob located between the directional pedals. The excessive number of turns required to achieve a significant directional pedal adjustment is a shortcoming previously reported.

64. At the bottom of each vertical Marconi Scale there was a green light signifying that electrical power was being supplied to the instrument. The pilot could be confused by the constant illumination of the bottom segment light. The light is unnecessary because of the pilot operated test features built into the airplane. The constant illumination of the bottom segment green light on the vertical scale of the Marconi instruments is a shortcoming. Additionally, the vertical scales of the Marconi instruments were unreadable in direct sunlight which is a shortcoming.

65. The pilot was provided only a small space for checklist and logbook storage. No provisions had been made for navigation, survival or personal equipment storage. These items had to be placed on top of mission-essential switches. The lack of adequate cockpit storage area for the pilot's equipment is a shortcoming previously noted.

66. Communication between cockpits was dependent solely on the ship's intercom system (ICS). Any ICS malfunction would preclude crew communication. Inclusion of corner mirrors in the front cockpit would enable the copilot to visually monitor the pilot, provide communication in the event of ICS failure, provide a means of monitoring weapons stores and provide a measure of visibility to the rear of the aircraft. Rearview mirrors should be installed in the front cockpit.

67. Mission planning is a preflight responsiblity and relies heavily on operator manual data. Due to many unforeseen circumstances, this information may be invalid before or shortly after takeoff. Since there will be many different configurations, weights, and cg's possible with the YAH-64, and the varying conditions under which it might operate, the availability of inflight information such as power available, fuel consumption, endurance, optimum power setting, etc., may mean the difference between successful mission completion or only a partial mission success. The operator's manual will be unuseable inflight during NOE. The YAH-64 helicopter should be provided with an inflight mission planning computer.

68. During the EDT 2 it was noted that no provisions had been made for the incorporation of a pilot's placarded checklist. The pilot's workload will be significantly reduced during the landing and takeoff phases of the YAH-64's mission through the use of placarded checklists. A placarded pretakeoff and prelanding checklist should be installed in the YAH-64.

station was adversely affected by the distortions around the canopy bracing and reflections in the flat plate canopy. The pilot had problems identifying other aircraft or objects due to the distortions. Light colored helmets or day-glow strip reflections from copilot's helmet were distracting to the pilot and interfered with his field of view. The numerous distortions and reflections throughout the canopy area are a shortcoming previously reported.

70. The pilot's field of view was also restricted by the overhead circuit breaker panel when the aircraft was in a left bank (20 to 45 degrees) and by the top support assembly of the blast shield at airspeeds greater than 120 KCAS. The pilot had to move his head or body in order to see around the structural assemblies. The restricted field of view caused by the overhead circuit breaker panel when the aircraft is in left banks of 20 to 45 degrees and by the top support assembly of the blast shield at airspeeds above 120 KCAS is a shortcoming previously reported.

Fuel Management

71. The YAH-64 helicopter fuel system incorporated a boost pump, a manual cross feed, and a transfer pump. A complete description of the fuel system is found in reference 12, appendix A. Procedures required the boost pump ON for operation above 10,000 feet. Because of the design of the fuel system, the boost pump would pump air when the aft fuel tank was drained, keeping the forward fuel check valve closed, thus, starving both engines of fuel. The possibility of having a dual engine fuel starvation with useable fuel remaining is a deficiency. A fault tree analysis on the current YAH-64 fuel system should be performed and the results should be included in the EDT-3 Familiarization Manual.

72. The fuel transfer pump was rated at 4.0 gallons per minute (GPM). During testing, actual transfer rate was approximately 2.5 GPM. At high power settings, the engines required 3.0 to 3.6 GPM. Thus, there exists a possibility of consuming fuel faster than it could be transferred. The inadequate fuel transfer rate is a shortcoming.

73. On numerous occasions during the evaluation, the pilot transferred or attempted to transfer fuel in the wrong direction. This occurred during high gain tasks where the pilot's attention was directed elsewhere. The pilot had no immediate indication of fuel transfer direction except for switch position. The fuel gauge only updated in 50-pound increments, which was too slow to determine transfer direction. Additionally, the pilot had no immediate indication that the fuel transfer pump was operational. The lack of adequate cockpit cues to determine positive fuel transfer and direction is a shortcoming. Consideration should be given to incorporating an automatic fuel transfer system.

Noise

74. Canopy drumming has been reduced from EDT 1 but was still objectionable. At airspeeds less than 50 KCAS and greater than 130 KCAS the canopy drumming was excessive and very annoying to the pilot. Additionally there was a marked increase in canopy drumming at airspeeds from 108 to 118 KCAS in high power climbs, and in bank angles greater than 30° with airspeeds greater than 90 KCAS. Due to the possibility of pilot fatigue that may be associated with canopy drumming, consideration should be given to performing a cockpit noise survey. Excessive canopy drumming is a shortcoming previously reported.

RELIABILITY, AVAILABILITY AND MAINTAINABILITY

75. The reliability, availability and maintainability of the aircraft was evaluated throughout the test program. During EDT 2 training and testing, 42 hours were flown in 16 working days. Maintenance down time was minimal. Similarly, during DT 1 and EDT 1, the aircraft was flown 92 hours in 77 workings days and 21.8 hours in 9 working days. The high availability of the YAH-64 is noteworthy. However, numerous maintenance related shortcomings were discovered and five equipment performance reports (EPR's) were submitted (app G). The following reliability and maintainability shortcomings were noted:

a. During ground handling, the tail wheel support assembly was damaged when the tail wheel locking pin was not released. The possibility of damaging the tail wheel support assembly during ground handling operation is a shortcoming previously reported.

b. Electrical power was required when pressure refueling the aircraft in order for automatic shutoff devices to function properly. If pressure refueling was attempted without electrical power, the automatic shutoff devices would be bypassed, and the forward fuel cell may be overserviced. The possibility of overservicing the forward fuel cell when pressure refueling is a shortcoming.

c. The illumination of the Oil Pressure Accessory Pump (OIL PRES ACC PMP) caution light during sideward flight above 40 KTAS is a shortcoming previously reported.

d. The auxiliary power unit (APU) fail caution light was activated by a reduction in APU oil pressure below 8 psi. There was no automatic shutoff for this caution light. Thus, it remained on in flight causing a distraction to the pilot. The APU fail caution light remaining illuminated in flight is a shortcoming.

e. The external power caution light illuminated during high power climbs. The caution light was activated by opening a door covering the external power receptacles. The problem probably originated due to air pressure opening the door slightly in high power climbs. The external power caution light illuminating during high power climbs is a shortcoming.

f. During preflight it was extremely difficult to determine the engine oil levels without first opening the engine cowling. The accepted procedure was to peer up through the fire access panel and view the oil sight gauge reflection on a piece of polished metal. This procedure was marginal at best. The difficulty in reading the engine oil sight gauges without opening the engine cowlings is a shortcoming.

g. After making a rotor brake locked start and with both engines at idle, the rotor brake occasionally slipped. The possiblity of the rotor brake slipping with both engines at flight idle is a shortcoming.

h. Both engine nose gear boxes of aircraft S/N 74-22249, leaked oil excessively throughout the testing. During one flight requiring high power, 1/4 of the oil capacity of one gearbox was lost (approximately 22 ounces). The helicopter's transmission and wing areas were continually covered with a film of oil making movement in these areas unsafe and creating a fire hazard. The excessive nose gearbox oil leakage is a shortcoming.

i. The external power source would not automatically accept the aircraft electrical loads. Electrical power was restored to the aircraft when the external power reset switch was cycled. The failure of the external power source to immediately assume the aircraft electrical load is a shortcoming.

j. The APU ON advisory light illuminating prior to the APU stabilizing at 100 percent rpm is a shortcoming.

k. In order to read the primary hydraulic accumulator pressure gauge during preflight, a cowling with 12 dzus fasteners must be removed and a mirror and flashlight used. The difficulty in reading the primary hydraulic accumulator pressure gauge is a shortcoming.

l. During engine start, the vertical scales of the Marconi torque gauge illuminated and fluctuated full scale while the digital readout increased to 189 percent before dropping down to correct readings. The torque gauge fluctuation during engine start is undesirable.

CONCLUSIONS

GENERAL

76. Numerous enhancing characteristics, deficiencies, and shortcomings reported during the DT I and the EDT I remain. Based on the EDT 2 flight test of the YAH-64 helicopter, the following conclusions were reached:

a. The YAH-64 helicopter continues to possess excellent potential as an attack helicopter (para 6).

b. Structural limitations imposed by the airworthiness release severly limited this evaluation (para 55).

c. The performance of the YAH-64 helicopter as tested in EDT 2 had markedly deteriorated as compared to the same aircraft as tested in DT I (para 7).

d. The tail rotor performance has markedly deteriorated from DT I (paras 6, 9, and 35).

e. The torque matching and turbine gas temperature limiting feature of the YT700-GE-700 engines were excellent (para 39).

f. The ASE OFF pitch-coupled dutch roll damping was slightly degraded from that observed during EDT 1 (para 27).

g. Five equipment performance reports were submitted (para 75).

h. Seven deficiencies and 43 shortcomings were identified (para 6).

i. The high availability of the YAH-64 is noteworthy (para 75).

ENHANCING CHARACTERISTICS

77. The starting procedure used in the YAH-64 is an enhancing characteristic (para 56).

DEFICIENCIES

78. The following deficiencies (in order of their importance) were identified:

a. The pilot's restricted forward field of view due to the excessive nose-high attitude during the landing approach (para 32).

*** b. The inability to control heading, ASE OFF, in left sideward flight at 15 to 40 KTAS (para 36 and 37).

c. The insufficient left directional control margin in right lateral accelerations (para 42).

***Previously reported (refs 1 and 2).

d. The possibility of having dual-engine fuel starvation with useable fuel remaining (para 71).

e. The low activation threshold of the low rpm rotor warning (para 40).

f. The lack of adequate cues to warn the pilot of a partial power engine malfunction (para 47).

**g. The excessive 4/rev lateral vibration (pilot seat) during the termination of approach and in level flight at airspeeds less than 50 KCAS and greater than 130 KCAS (para 50).

SHORTCOMINGS

79. The following shortcomings (in order of their importance) were identified:

*a. The restricted field of view due to the nose-high attitude during IRP climbs (para 19).

*b. The restricted field of view caused by the overhead circuit breaker panel when the aircraft is in left bank angles of 20 to 45 degrees and the top support assembly of the blast shield at airspeeds above 120 KCAS (para 70).

**c. The YAH-64's handling qualities in sideward flight (airspeeds greater than 20 KTAS) at the critical azimuth, ASE ON (para 37).

*d. The large longitudinal control displacement during takeoffs (para 31).

*e. The excessive longitudinal cyclic changes with power application (paras 20 and 31).

f. The moderate vibration in right sideward, rearward flight, and in high power climbs (108 to 118 KCAS) (para 53).

*g. The excessive canopy drumming (para 74).

**h. The ASE OFF pitch-coupled dutch roll (para 27).

i. The poor anthropometric design of the cyclic grip (para 57).

j. The increase in pilot workload (attitude HOLD ON) when attempting to obtain and maintain precise airspeeds greater than 120 KIAS (para 46).

*k. The numerous distortions and reflections throughout the canopy (para 69).

***l. The nonlinear trim requirement, making precise airspeed and attitude control difficult between 60 and 100 KCAS (para 17).

m. Random uncommanded yaw excursions in steady state banks of 40 degrees or greater (para 24).

*Previously reported (ref 1).
**Previously reported (ref 2)
***Previously reported (refs 1 and 2)

*n. The excessive directional control jump (para 16).

o. The excessive longitudinal and lateral breakout (plus friction) force (para 15).

p. The weak longitudinal and lateral control force gradients (para 15).

q. The weak longitudinal and lateral centering control (para 15).

r. The random yaw "shuffle" (para 18).

s. The lack of adequate cockpit cues to determine positive fuel transfer and direction (para 73).

t. The inadequate fuel transfer rate (para 72).

u. Shallow stick free maneuvering stability gradient (para 24).

v. Inadvertent directional inputs by the pilot due to the excessive brake pedal pressure required during braking (para 30).

w. The high inherent friction in the engine power levers assembly (para 41).

*x. The poor location of engine fuel switches (para 59).

y. The poor anthropometric design and location of the canopy jettison handle (para 58).

z. Inadequate cockpit cues to determine parking brake status (para 60).

*aa. The lack of adequate cockpit storage area for the pilot's equipment (para 65).

bb. The vertical scales of the Marconi instruments were unreadable in direct sunlight (para 64).

cc. The poor location of the tail wheel lock/unlock light (para 61).

**dd. The illumination of the oil pressure accessory pump caution light during sideward flight above 40 KTAS (para 75c).

*ee. The possibility of damaging the tail wheel support assembly during ground handling (para 75a).

ff. The possibility of overservicing the forward fuel cell when pressure refueling (para 75b).

gg. The excessive nose gearbox oil leakage (para 75h).

*hh. The lack of a longitudinal seat adjustment (para 62).

ii. The possibility of the rotor brake slipping with both engines at idle (para 75g).

*Previously reported (ref 1).
**Previously reported (ref 2).

jj. The APU FAIL caution light remaining illuminated in flight (para 75d).

kk. The EXTERNAL POWER caution light illuminating during high power climbs (para 75c).

ll. The difficulty in reading the engine oil sight gauges without opening the engine cowlings (para 75f).

mm. The failure of the external power source to immediately assume the aircraft electrical load (para 75i).

nn. The APU ON advisory light illuminating prior to the APU stabilizing at 100 percent rpm (para 75j).

oo. The constant illumination of the bottom segment green light on the vertical scale of the Marconi instruments (para 64).

pp. The difficulty in reading the primary hydraulic accumulator pressure gauge (para 75k).

*qq. The excessive number of turns required to achieve a significant directional pedal adjustment (para 63).

*Previously reported (ref 1).

RECOMMENDATIONS

80. The following recommendations are made:

a. The enhancing characteristic noted in paragraph 77 be included in future Army aircraft.

b. The deficiencies noted in paragraph 78 be corrected prior to Engineering Design Test 3 (EDT 3).

c. The shortcomings noted in paragraph 79 be corrected.

d. An evaluation be performed to determine the effects of yaw ASE hard-overs during ground taxi operations (to include running landings) (para 29).

e. An NOE evaluation should be performed to determine the ramifications of restricted field of view problems and aircraft attitudes on the NOE mission (para 33).

f. Additional hover and lowspeed testing should be accomplished at higher density altitudes (para 35).

g. A cockpit noise survey be performed in all flight regimes (para 74).

h. The YAH-64 helicopter should be provided with an inflight mission planning computer (para 67).

i. Perform a fault tree analysis on the current YAH-64's fuel system and the results should be included in the EDT-3 familiarization manual (para 71).

j. An automatic fuel transfer system should be incorporated (para 73).

k. Simulated IMC flight in moderate or greater turbulence should be evaluated prior to a final judgment of IMC flight characteristics (para 46).

m. A placarded pretakeoff and prelanding checklist should be installed in the YAH-64 (para 68).

n. Rearview mirrors should be installed in the front cockpit (para 66).

APPENDIX A. REFERENCES

1. Final Report, USAAEFA Project No. 74-07-2, *Development Test 1, Advanced Attack Helicopter Competitive Evaluation, Hughes YAH-64 Helicopter,* December 1976.

2. Final Report, USAAEFA Project No. 77-36, *Engineer Design Test 1, Hughes YAH-64 Advanced Attack Helicopter,* September 1978.

3. Letter, AVRADCOM, DRDAV-EQI, 5 March 1979, subject: Engineer Design Test 2 (EDT 2) of YAH-64 Advanced Attack Helicopter.

4. Test Plan, USAAEFA, Project No. 78-23, *Engineer Design Test 2, YAH-64 Advanced Attack Helicopter,* March 1979.

5. Letter, AVRADCOM, DRDAV-EQ, 8 April 1979, subject: Airworthiness Release for the Engineer Design Test (EDT 2) of the YAH-64, S/N 74-22249, Revised 11 April 1979 and 16 April 1979.

6. Letter, AVRADCOM, DRDAV-EQ, 13 April 1979, subject: Airworthiness Release for the Engineer Design Test (EDT 2) of the YAH-64, S/N 74-22248, Revised 16 April 1979 and 19 April 1979.

7. Flight Test Manual, Naval Air Test Center, FTM No. 102, *Helicopter Performance,* 28 June, 1968.

8. Flight Test Manual, Naval Air Test Center, FTM No. 101, *Helicopter Stability and Control,* 10 June 1968.

9. Training Manual, Hughes Helicopter Company, *Hughes YAH-64 Advanced Attack Helicopter,* 1 April 1976.

10. Flight Manual, Hughes Helicopter Company, Report No. 77-TM-8001-2, *YAH-64 Advanced Attack Helicopter,* 19 May 1976, reissued September 1978.

11. EDT 2 Familiarization Manual, Hughes Helicopter Company, *YAH-64 Helicopter,* January 1979.

APPENDIX B. DESCRIPTION

1. The YAH-64 advanced attack helicopter (fig. 1), is a tandem, two-place twin turbine-engine, single-main-rotor aircraft manufactured by Hughes Helicopters, a division of Summa Corporation. The aircraft is designed to deliver various combinations of ordnance stored both internally and externally on the four wing store positions during day and night combat conditions. Photos 1 through 4 are views of the YAH-64 Mod 2B version which was flown during EDT 2. Aircraft S/N 74-22248 was configured with a mockup of the Martin Marietta Pilots Night Vision System (PNVS) and aircraft S/N 74-22249 with the Northrop Aircraft Corporation PNVS (photos 5 and 6). Basic design information is listed below. A complete description of the aircraft is contained in references 9, 10, 11, appendix A.

DIMENSIONS AND GENERAL DATA

Main Rotor	EDT-2 Mod 2B
Diameter (ft)	48
Blade chord (in.)	21.0*
Main rotor blade area (ft^2)	150.88
Main rotor disc area (ft^2)	1809.56
Main rotor solidity (thrust weighted, no tip loss)	0.092
Airfoil	HH-02**
Twist	9 deg washout
Number of blades	4
Rotor speed at 100 percent Np (rpm)	289.3
Normal tip speed (ΩR) (ft/sec)	727.09

Tail Rotor

Diameter (ft)	8.33
Chord constant (in.)	10
Tail rotor blade area (ft^2)	10
Tail rotor disc area (ft^2)	54.54
Tail rotor solidity	0.2475
Airfoil	NACA 632-414 (modified)
Twist (degrees)	0
Number of blades	4
Rotor speed at 100 percent Np (rpm)	1411
Distance from main rotor mast centerline (C_L) (ft)	28.49
Normal tip speed (ΩR) (ft/sec)	615.44
Teetering angle (deg)	35

*Includes tips
**Outer 20 inches swept back 20 degrees and transitioned to an NACA 64A 006 airfoil.

Horizontal Stabilizer	DT-1 Phase 1	EDT-1 Mod 1	EDT-2 Mod 2B
Weight (lb)	106	37.1	112.8
Area (ft^2)	32.95	32.99	32.99
Span (ft)	11.03	11.46	11.46
Tip chord (ft)	1.97	1.94	1.94
Root chord (ft)	3.90	3.81***	3.81***
Airfoil	NACA 0015	NACA 0015	NACA 0015
Geometric aspect ratio	3.69	3.98	3.98
Incidence of chord line (deg)	Zero	-1	+1
Sweepback of leading edge (deg)	25	0	0
Sweepback of trailing edge (deg)	6.62°	-19.13° (swept forward)	-19.13° (swept forward)
Dihedral (deg)	0	0	0

Vertical Stabilizer

Area (from boom C_L) (ft^2)		32.80	32.80
Span (from boom C_L) (in.)		113.0	113.0
Root chord (at boom C_L) (in.)		47.84	47.84
Geometric aspect ratio		2.77	2.77
Airfoil		NACA 4415 modified at root (C_L boom) tapering to NACA 4416 at 66 in. from boom C_L	NACA 4415 modified at root (C_L boom) tapering to NACA 4416 at 66 in. from boom C_L
Leading edge sweep (deg)			
(to 66 in. from boom C_L)		32.28	32.28
(from 66 to 113 in. from boom C_L)		32.28	25.68
Rudder deflection NOTE: Below fold joint deflection should fair from 12 deg at top to half ellipse at bottom		12	12 + 10° tab extension (above fold joint)

Wing

Span (ft)		16.33	16.33
Mean aerodynamic chord (in.)		45.9	45.9
Total area (ft^2)		61.56	61.56
Flap area (ft^2)		8.71	8.71
Airfoil at root		NACA 4418	NACA 4418

***Reference is 3.2 inches from centerline (C_L)

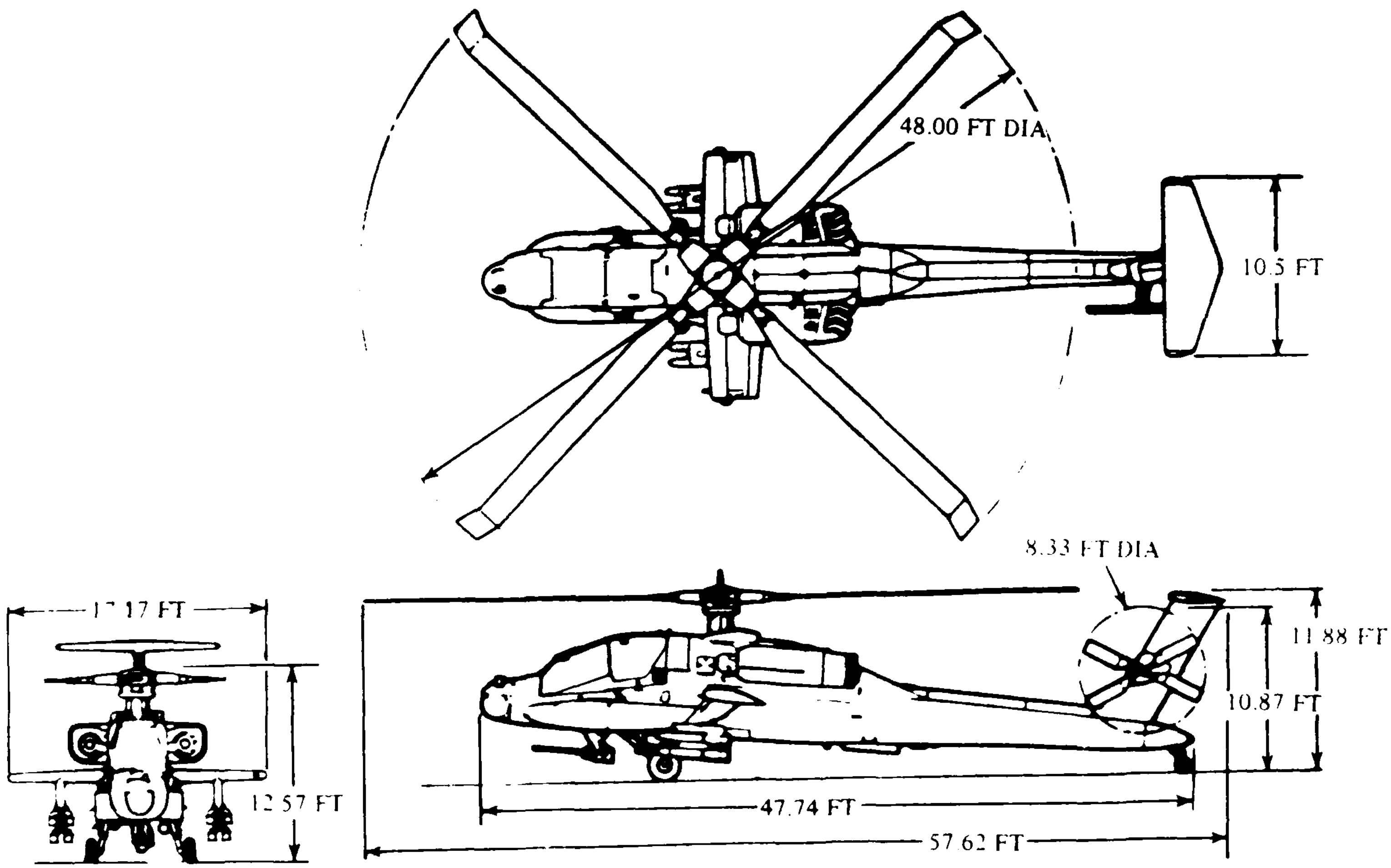


Figure 1. Aircraft Dimensions

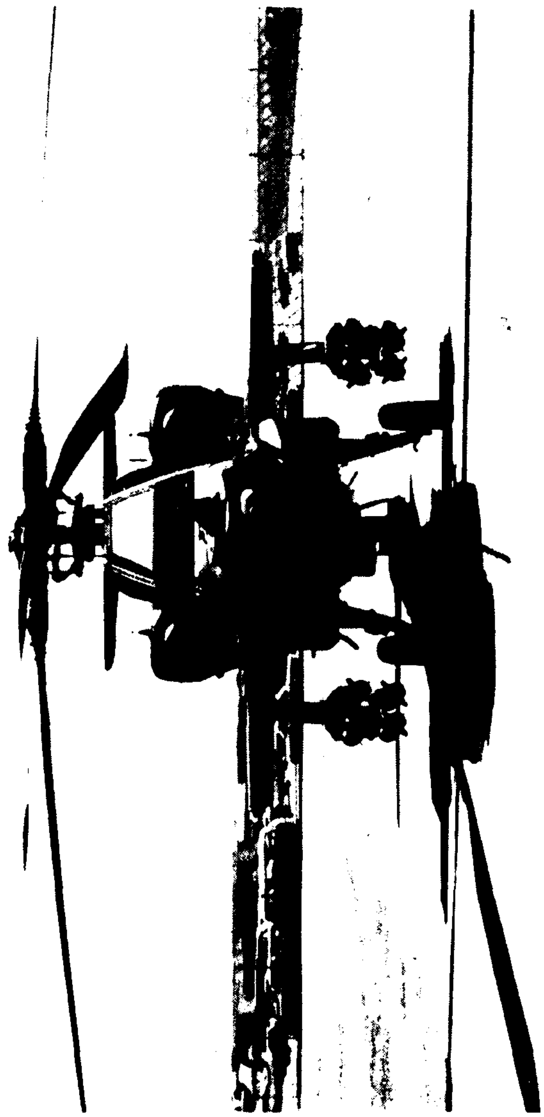


Photo 1. Front View

Photo 2. Left Front Quartering View

Photo 3. Right Front Quartering View

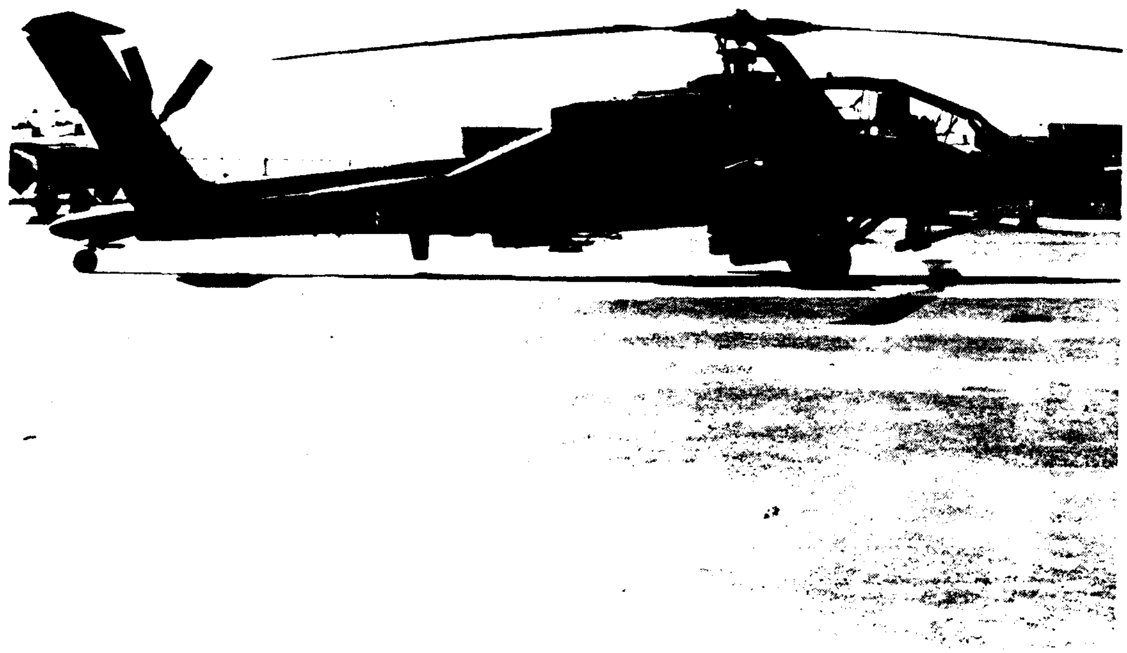


Photo 4. Right Side View

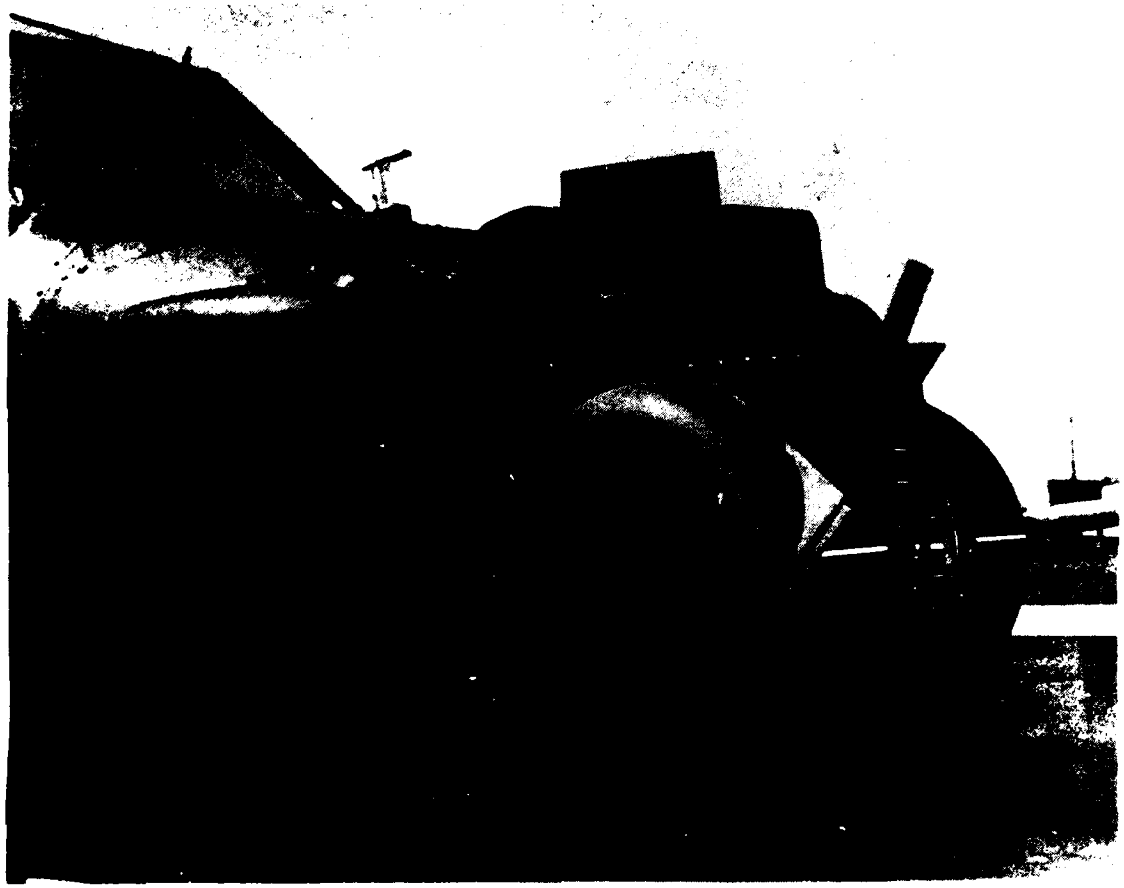


Photo 5. YAH-64 S/N 74-22248 with Martin Marietta PNVS

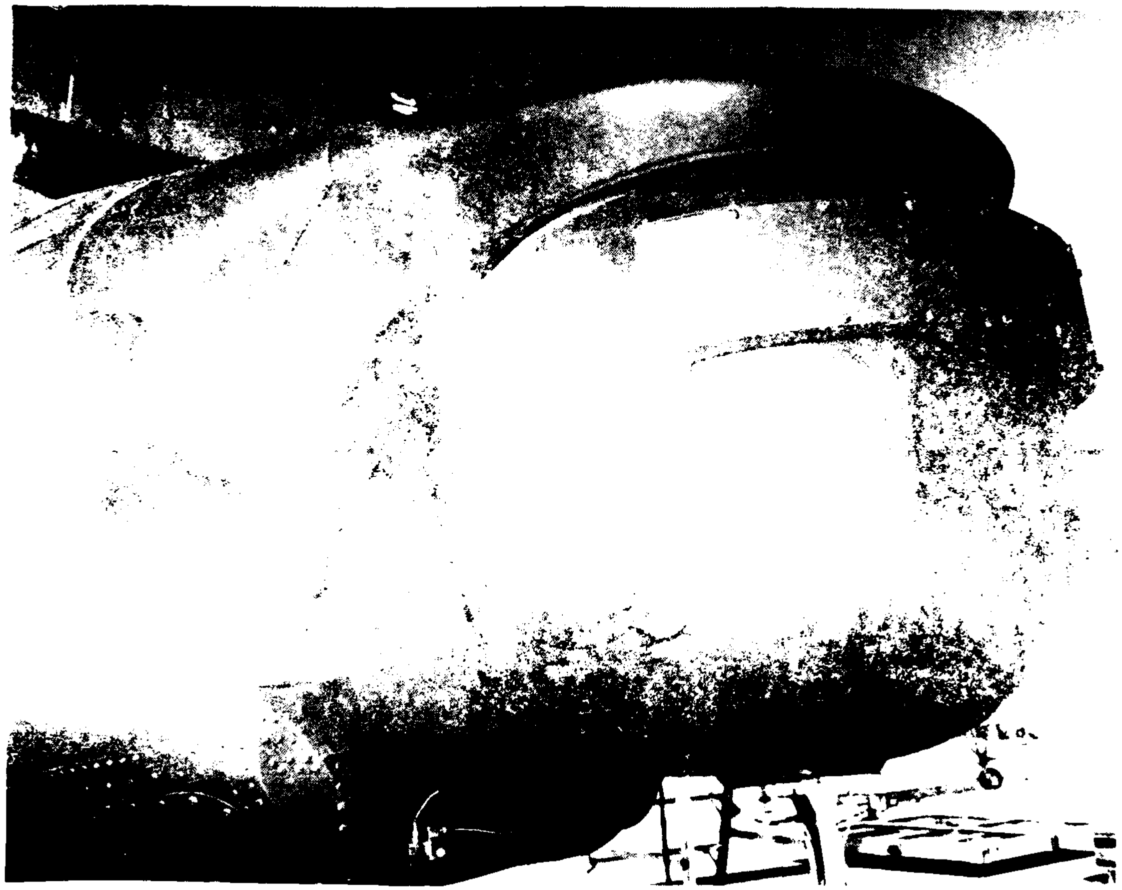


Photo 6. YAH-64 S/N 74-22249 with Northrup PNVS

FLIGHT CONTROL DESCRIPTION

2. The YAH-64 helicopter employs a single hydromechanical irreversible flight control system. The hydromechanical system is mechanically activated with conventional pilot cyclic, collective and pedal controls, through a series of push-pull tubes going to four airframe-mounted hydraulic servo actuators. The four hydraulic servo actuators control longitudinal cyclic, lateral cyclic, collective, tail rotor collective pitch, and are powered by two independent 3000-psi hydraulic systems which are powered by hydraulic pumps mounted on the accessory gearbox to allow full operation under a dual-engine failure condition. An automatic stabilization equipment (ASE) system is installed to provide closed-loop rate stability augmentation control (SAS) of limited 10 percent authority in pitch and roll and 20 percent authority in yaw. Included with the ASE are an attitude retention mode and a wing flap control system. A force trim system (FTS) is incorporated in cyclic and pedal controls to provide a control force gradient with control displacement from a selected trim position. A force trim interrupter button, located on the cyclic grip, provides a momentary interruption of the force trim in all axes simultaneously to allow the cyclic or pedal control to be placed in a new trim position. The collective lever has a mechanical friction device and a 1g balance spring to balance the collective control forces. Full control travel is approximately 10 inches in the cyclic longitudinal control, 10 inches in the lateral control, 12 inches in the collective control, and 6 inches in the rudder pedals.

Cyclic Control System

3. The cyclic control system consists of dual-tandem cyclic control attached to individual support assemblies at the cyclic control (fig. 2). The support assembly houses the primary longitudinal and lateral control stops, and two linear variable displacement transducers (LVDT) designed to measure electrically the longitudinal and lateral motions of the cyclic for ASE computer inputs. A series of push-pull tubes and bell cranks transmits the motion of the cyclic control to servo actuators and the mixer assembly. Motion of the mixer assembly positions the nonrotating swashplate, which is linked to the rotating swashplate to control the main rotor blades in cyclic and collective pitch (figure 3). The handgrip utilized on the YAH-64 cyclic stick is similar to the OH-58 handgrip.

Cyclic Force Trim System (FTS)

4. The cyclic control FTS provides cyclic control feel and allows close repositioning with the use of the cyclic trim button. Individual longitudinal and lateral electromagnetic brake clutches incorporating trim feel springs are provided for control centering and a control force gradient. The system is operational whenever electric power is applied. The electromagnetic brake clutch is powered by 28 VDC and is protected by a trim circuit breaker panel. In the event of complete electrical DC failure, the FTS is disabled, and cyclic control movement will not be resisted longitudinally, or laterally.

Collective Control System

5. The collective pitch control system consists of dual-tandem controls connected by push-pull tubes and bell cranks (fig. 4). Located at each collective control base assembly unit are the primary control stop an LVDT and 1g balance spring. The LVDT supplies electrical inputs to the ASE and to the load-demand spindle of the engine hydromechanical unit (HMU), which is a section of the fuel control unit for the YT700-GE-700 engines. The input to the HMU provides collective pitch

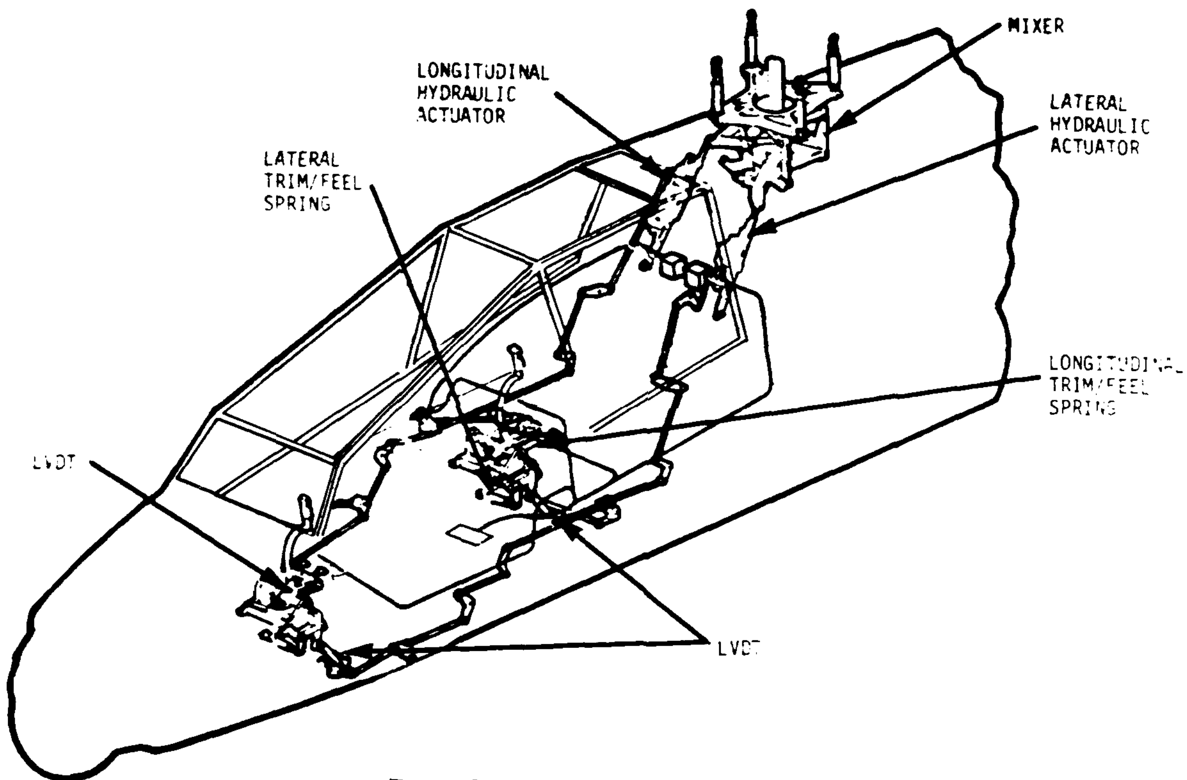


Figure 2. Cyclic Control Subsystem

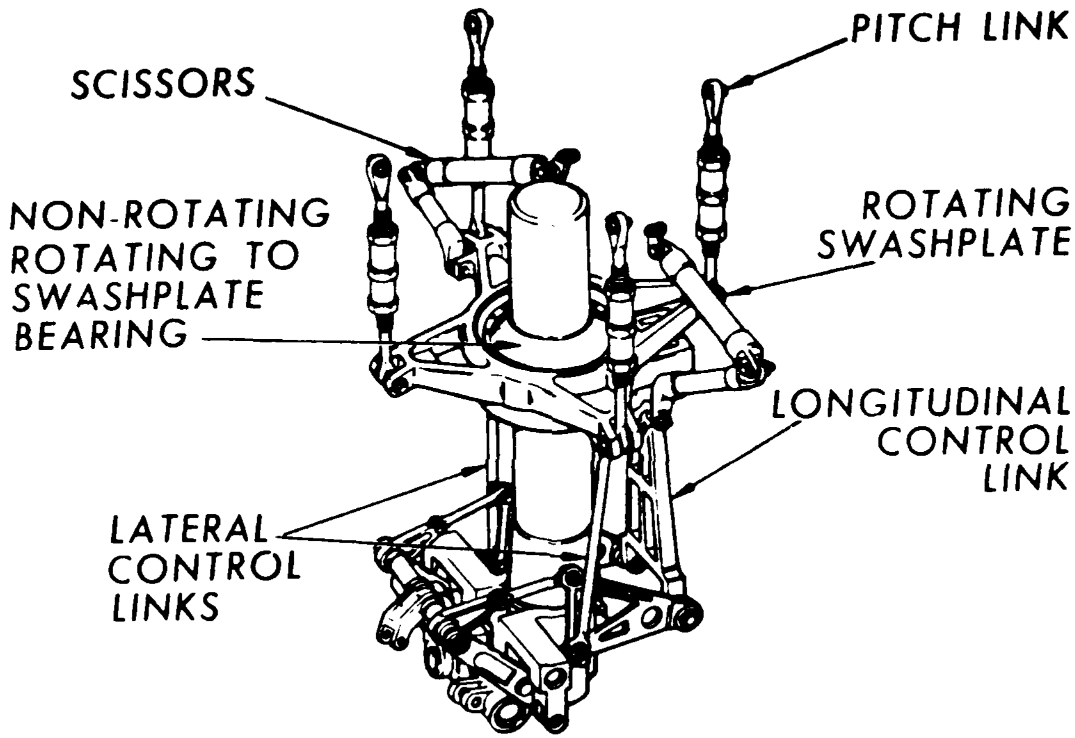


Figure 3. Main Rotor Swashplate Assembly

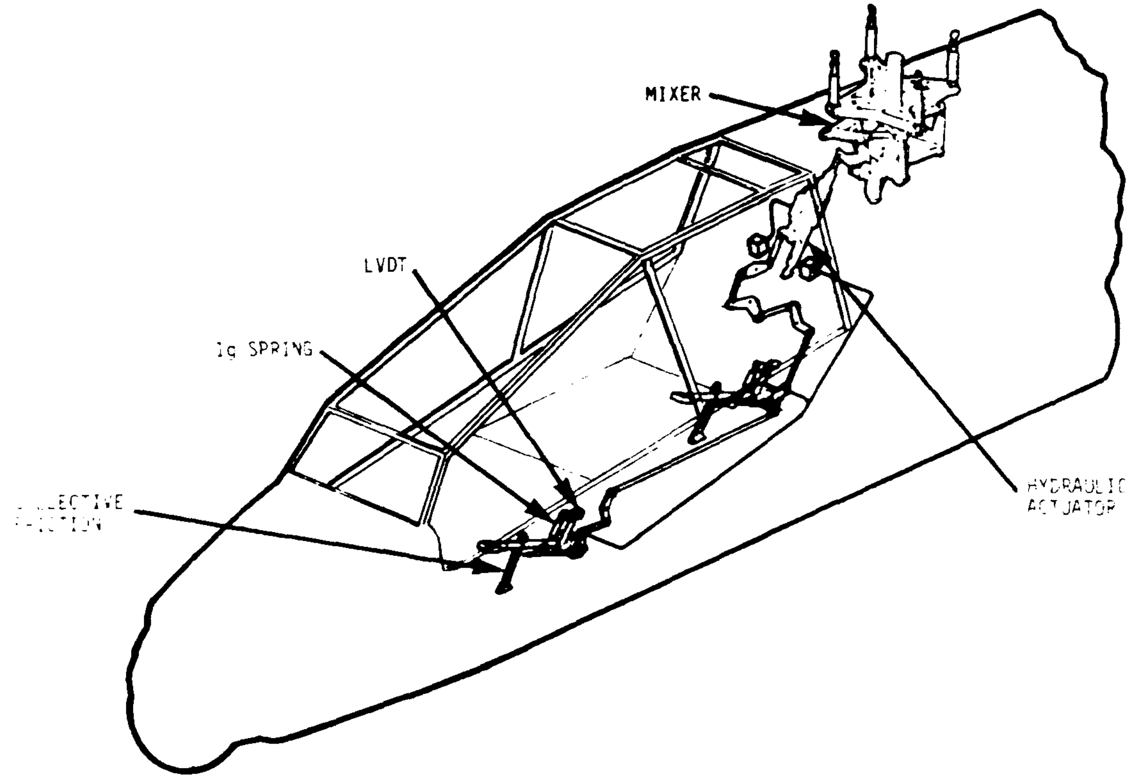


Figure 4. Collective Control Subsystem

compensation which acts as a main rotor droop compensator. Additionally, the collective LVDT provides inputs to the wing flap control system. A series of push-pull tubes and bell cranks transmits collective movements to the collective servo actuator, the main rotor mixer unit, and the main rotor.

6. A switch box assembly at the top of each collective control contains numerous switches. The engine-cut button (non standard) provides for rapid deceleration of the engines to ground-idle in event of an emergency where the pilot cannot release the collective control to retard the speed selectors. Both collective controls incorporate adjustable friction devices.

Directional Control System

7. The directional control system (fig. 5) consists of the following components: two sets of adjustable directional control pedals; two sets of wheel brake cylinders; and a series of push-pull tubes and bell cranks which extend the length of the airframe via the tail rotor servo actuator and terminate at the tail rotor gearbox. Attached to each directional pedal assembly are the primary tail rotor control stops and one LVDT.

Directional Control

8. The pedal trim gradient system incorporates a similiar magnetic clutch and spring assembly as previously described for the cyclic control (para 3). The trim gradient is to help reduce control sensitivity and control force disharmony.

HYDRAULIC SYSTEM

General

9. The hydraulic system consists of four hydraulic servo actuators powered simultaneously by two independent 3000-psi hydraulic systems. The two systems (primary and utility) are driven off the accessory gearbox utilizing variable displacement pumps, independent reservoirs, and accumulators. The APU drives all accessories, including the hydraulic pumps, when the aircraft is on the ground and the rotor is not turning.

Primary Hydraulic System

10. The primary hydraulic system consists of a 30 cubic inch capacity reservoir, which is air charged to 20 to 60 psig using air from the shaft-driven compressor; an accumulator, which has a nitrogen precharge of 1600 psi, designed to reduce surges in the hydraulic system; and a primary manifold that redirects the fluid to the lower side of the dual-tandem actuators of the four servo actuators. The primary system provides the hydraulic pressure for the ASE.

Utility Hydraulic System

11. The utility hydraulic system consists of a 270 cubic inch reservoir and a 3000-psi accumulator to drive the APU starting motor and to provide hydraulic pressure to the flight control system in the event of a dual hydraulic system failure. Each servo actuator simultaneously receives pressure from the primary and utility systems to drive the dual-tandem actuators. This design allows the remaining system

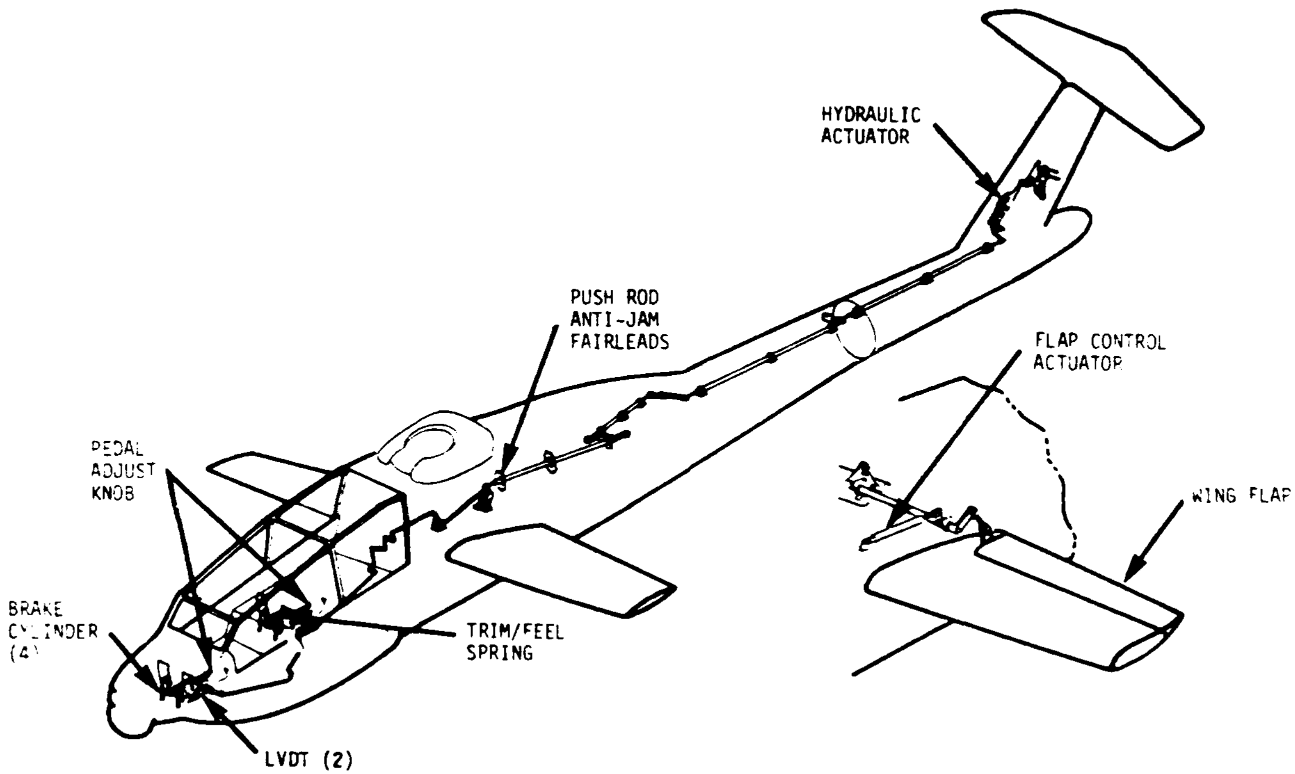


Figure 5. Directional Control Wing Flap Subsystem

to automatically continue powering the servos in the event of a hydraulic system failure. The utility manifold directs fluid to the upper side of the servo actuators, the stores pylon system (which actuates the pylons in elevations from +10 to -28 degrees), wing flaps, gun azimuth and elevation, and rotor brake. Other manifold functions include a low fluid sensor which isolates all auxiliary functions to provide hydraulic pressure only to the servo actuators and rotor brake and a low-pressure sensor which isolates the accumulator to remain as a reserve hydraulic source for the servo actuators.

Automatic Stabilization Equipment System

12. The automatic stabilization equipment (ASE) system (fig. 6) consists of four subsystems: A stabilization augmentation system (SAS), a flap control system, a longitudinal force feel system (FFS), and a back-up control system (BUCS). The FFS and BUCS were not operational during this evaluation.

Stability Augmentation System

13. The SAS has five functions. Its primary function is to provide three axes angular rate damping with the authority limited to 10 percent control travel in pitch and roll and 20 percent in yaw. A second function of the SAS is to provide control augmentation in pitch, roll and yaw. Although a part of SAS circuitry, this subsystem is generally referred to as the control augmentation system (CAS). The third function of SAS is to provide a limited authority (50 percent of SAS authority) attitude hold feature in the pitch and roll axes. The fourth function, which is an outgrowth of the attitude hold feature, is to provide a degree of increased longitudinal static stability. The fifth function, turn coordination, is achieved by utilizing one of the channels of the yaw SAS in conjunction with sideslip inputs.

14. The ASE computer receives flight control inputs via the LVDT. The ASE computer also receives inputs from the pitch, roll and yaw rates gyros; a roll and pitch attitude (vertical) gyro; a sideslip sensor; and an airspeed sensor (fig. 7). The analog computer integrates all inputs to provide smooth control signals for the SAS control servos. The computer has a built-in test equipment (BITE) system which allows the pilot to check the automatic hardover monitoring circuits prior to rotor engagement. Additionally, in flight the automatic servo monitor system is designed to compare actuator position with SAS commands and will disable the particular SAS axis if the two are not compatible (hardover protection). ASE cockpit control switches are provided to the pilot only; however, SAS disengagement switches are located on the cyclic control grips for both pilots.

15. The pitch SAS is dual-channel, with each channel providing ±5 percent control authority. Figure 8 is a block diagram of the pitch SAS. Channel 2 receives inputs from the pitch rate gyro to provide part of the total system's pitch rate damping. All washout times referred to in this report have been computed for 3 time constants which is equivalent to 95 percent washout. This signal is washed out after approximately 30 seconds (trim engaged) so that the SAS actuator will recenter and not oppose steady state maneuvers such as diving flight.

16. A fast washout (≈3.5 seconds) is provided when the force trim release button is pressed to allow rapid centering of the SAS actuator during aircraft retrimming. The CAS receives an input from the longitudinal control LVDT and works through channel 1 to provide a stick quickening function. CAS washout times are ≈20.4 seconds normally, and ≈3.5 seconds with the force trim release button depressed. The CAS inputs are eliminated when the attitude hold feature is selected. The sum of channel 1 rate damping and CAS inputs is limited to ±5 percent of control travel.

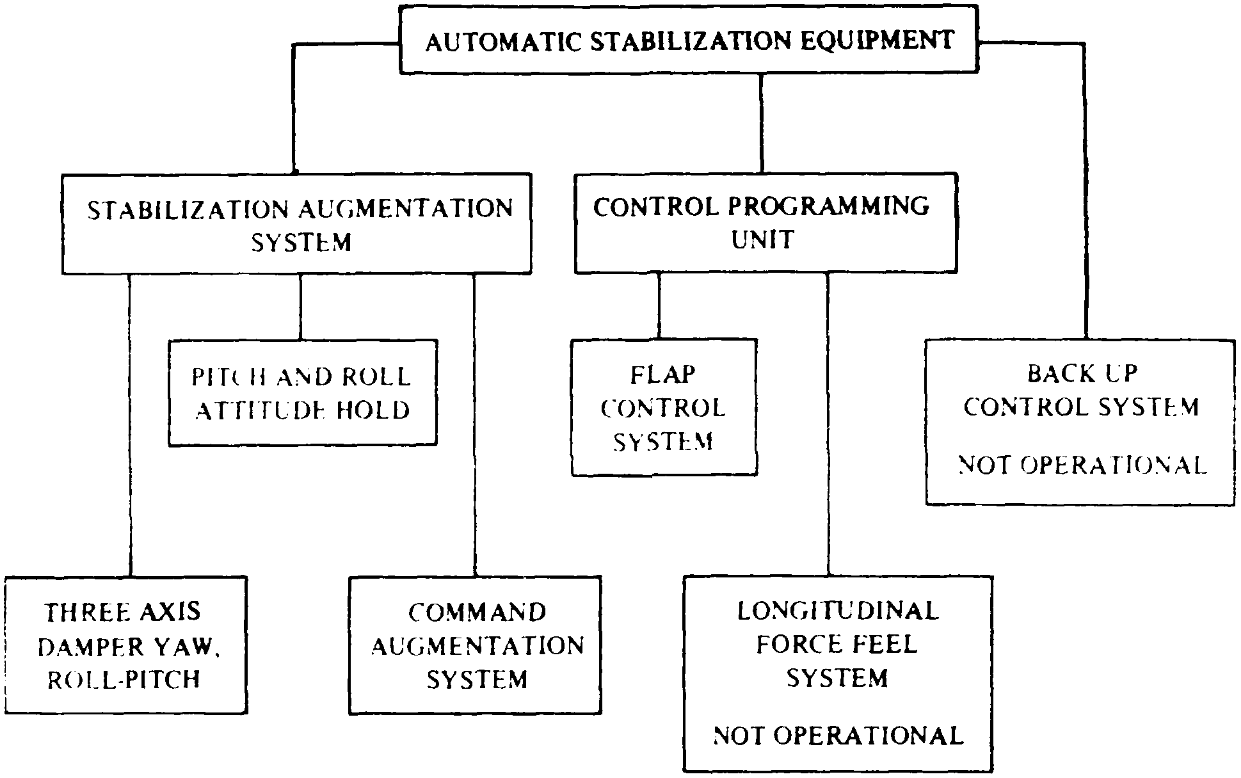


Figure 6. Automatic Stabilization Block Schematic

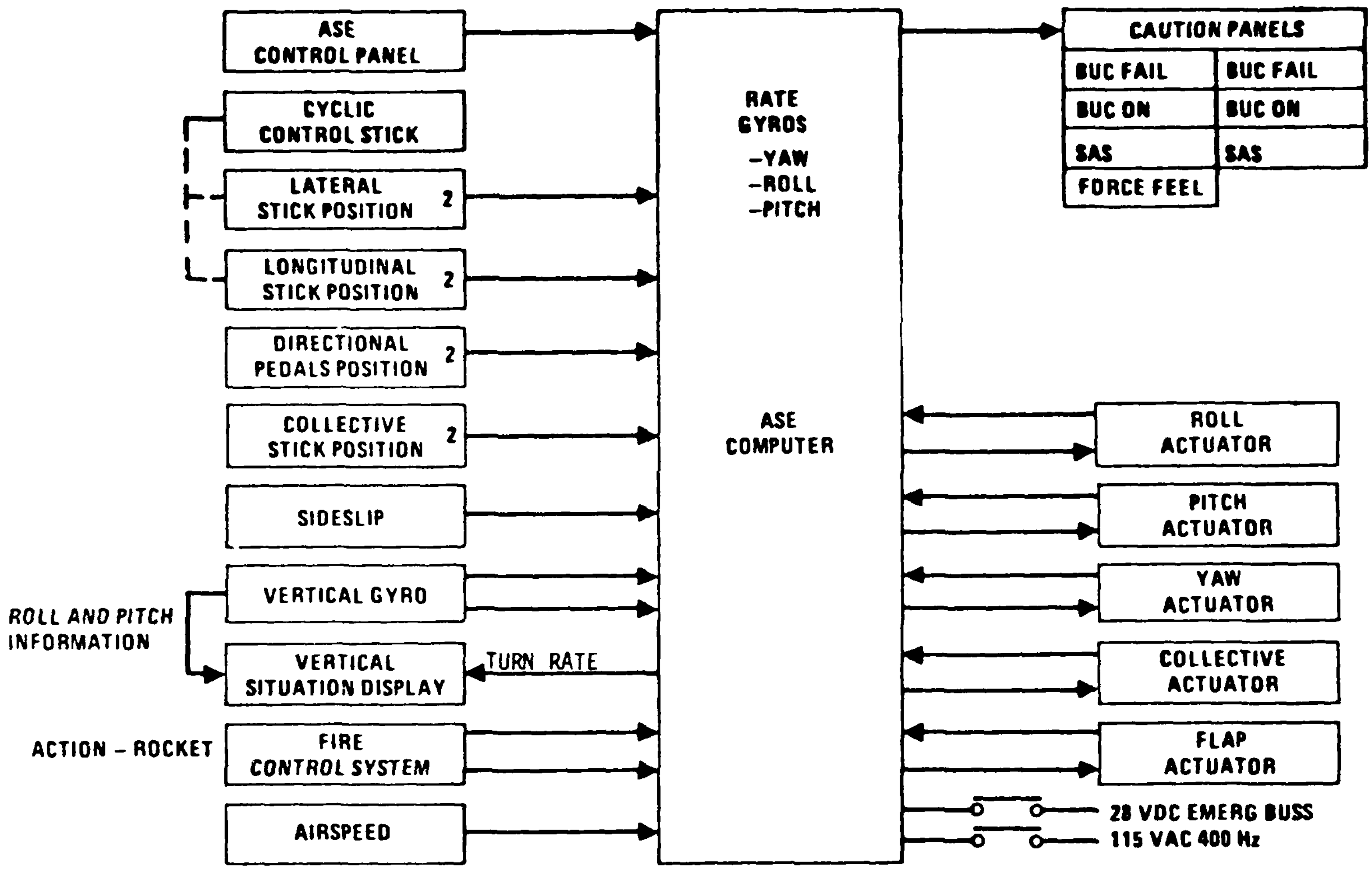


Figure 7. Automatic Stabilization Equipment Block Diagram

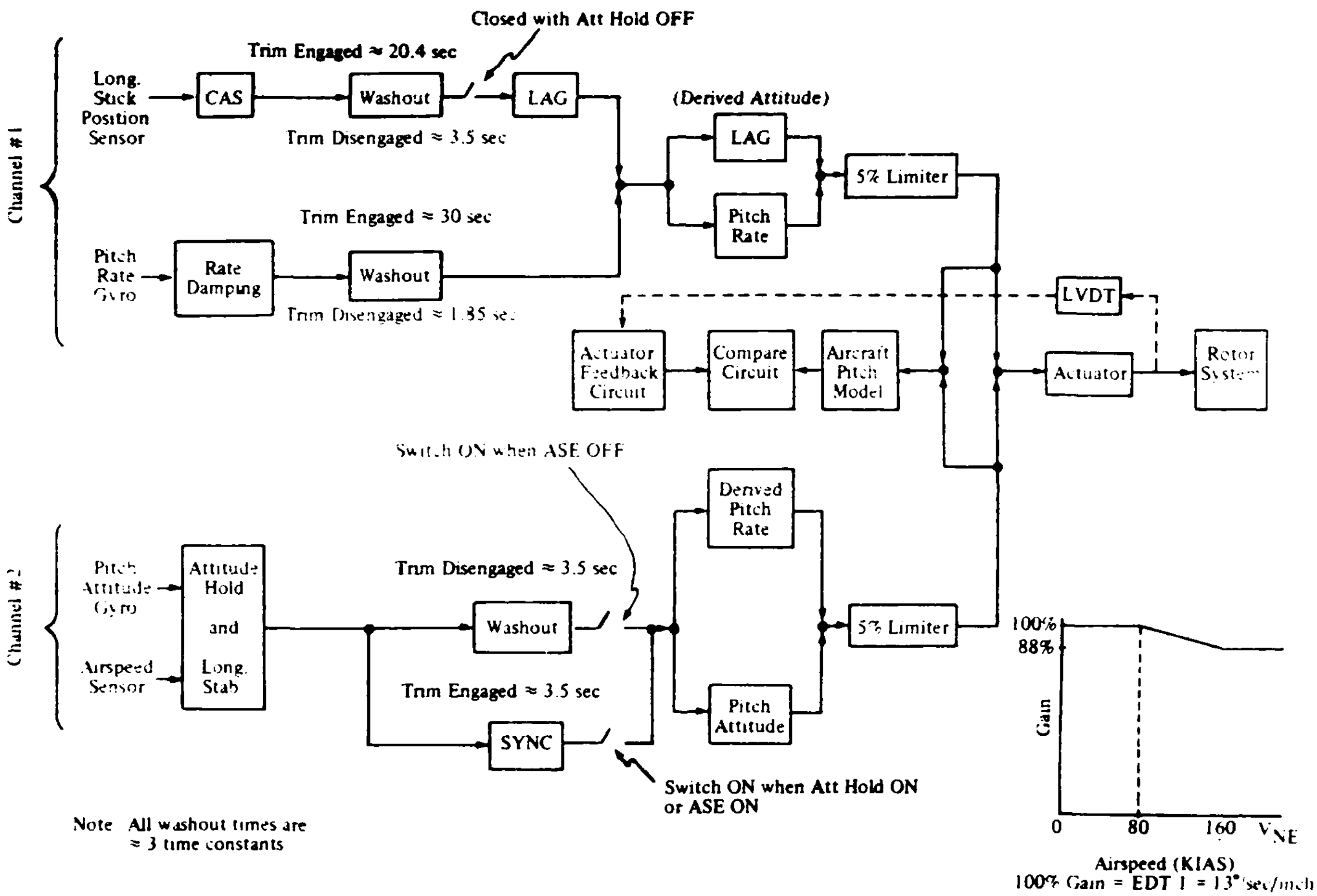


Figure 8. Pitch SAS

17. Channel 2 of the pitch SAS receives inputs from the pitch attitude gyro and the airspeed sensor. A pitch rate is then derived and utilized to provide a rate damping command from channel 2. Another signal, proportional to pitch attitude and airspeed provides both pitch attitude hold and some tailoring of control position static longitudinal stability. The attitude washout time is ≈3.5 seconds and presently independent of the force trim release button position.

18. The pitch rate damping functions are saturated if an external disturbance causes an aircraft pitch rate change greater than 11 deg/sec (rate obtained over a one second interval). The pitch attitude hold function is saturated by a deviation from trim pitch attitude of 10 degrees (change in attitude obtained over a one second interval).

19. The roll SAS is similar to the pitch SAS, differing primarily in the gain and time constants. Figure 9 is a block diagram of the roll SAS. Channel 1 receives inputs from the roll rate gyro for rate damping and from the lateral control position LVDT for the CAS. Washout circuits are provided for the rate signals and CAS signals. Rate damping washout times are 30 seconds normally and 4.4 seconds with force trim release button depressed. The CAS washout times are 15 seconds normally and 3.6 seconds with the force trim release button depressed. Due to an extremely fast washout time the CAS inputs in roll with the attitude hold engaged have very little effect. The operation of the roll CAS differs from the pitch CAS in that it does not serve as a stick quickener. The roll CAS inputs are lagged and act to prevent a roll rate decrease due to rate damping functions. Figure 10 shows the effect of roll CAS on aircraft roll response.

20. Channel 2 of the roll SAS receives its input from the roll attitude gyro, a roll attitude hold function, and a rate damping function utilizing derived roll rate. The attitude signal washout time is ≈3.5 seconds.

21. The roll rate damping function is saturated with a 38 deg/sec roll rate (change in rate obtained over a one second interval). The roll attitude hold function is saturated by a deviation from trim roll attitude of 36 degrees (change in attitude obtained over a one second interval).

22. The yaw SAS is also dual-channel with each channel providing ±16 percent of yaw actuator authority. The sum of the two channel inputs is limited to ±20 percent by the yaw actuator itself. Figure 11 is a block diagram of the yaw SAS. Channel 1, which receives inputs from the yaw rate gyro, pedal position sensors, and the sideslip vane, functions to provide rate damping, pseudo-attitude hold, control augmentation, and zero sideslip retention. The rate damping subsystem uses yaw rate gyro data to compute a rate damping signal and a lagged rate signal which provides the pseudo-attitude hold.

23. The yaw CAS inputs are computed from the pedal position sensors, and are summed with the rate plus lagged rate signal. This combined signal has a washout time of 15 seconds normally and 3.5 seconds with the force trim release button depressed. This washout out command is then augmented by a zero sideslip retention command down to airspeeds of 52 KIAS when decelerating or airspeeds above 62 KIAS when accelerating.

24. Channel 2 of the yaw SAS has a rate damping plus lagged rate CAS and washout circuitry identical to channel 1 and utilizes the same yaw rate gyro and pedal position inputs. A separate function of channel 2 uses roll attitude, roll rate, and airspeed to compute a trim rate signal to supplement the sideslip signal of channel 1,

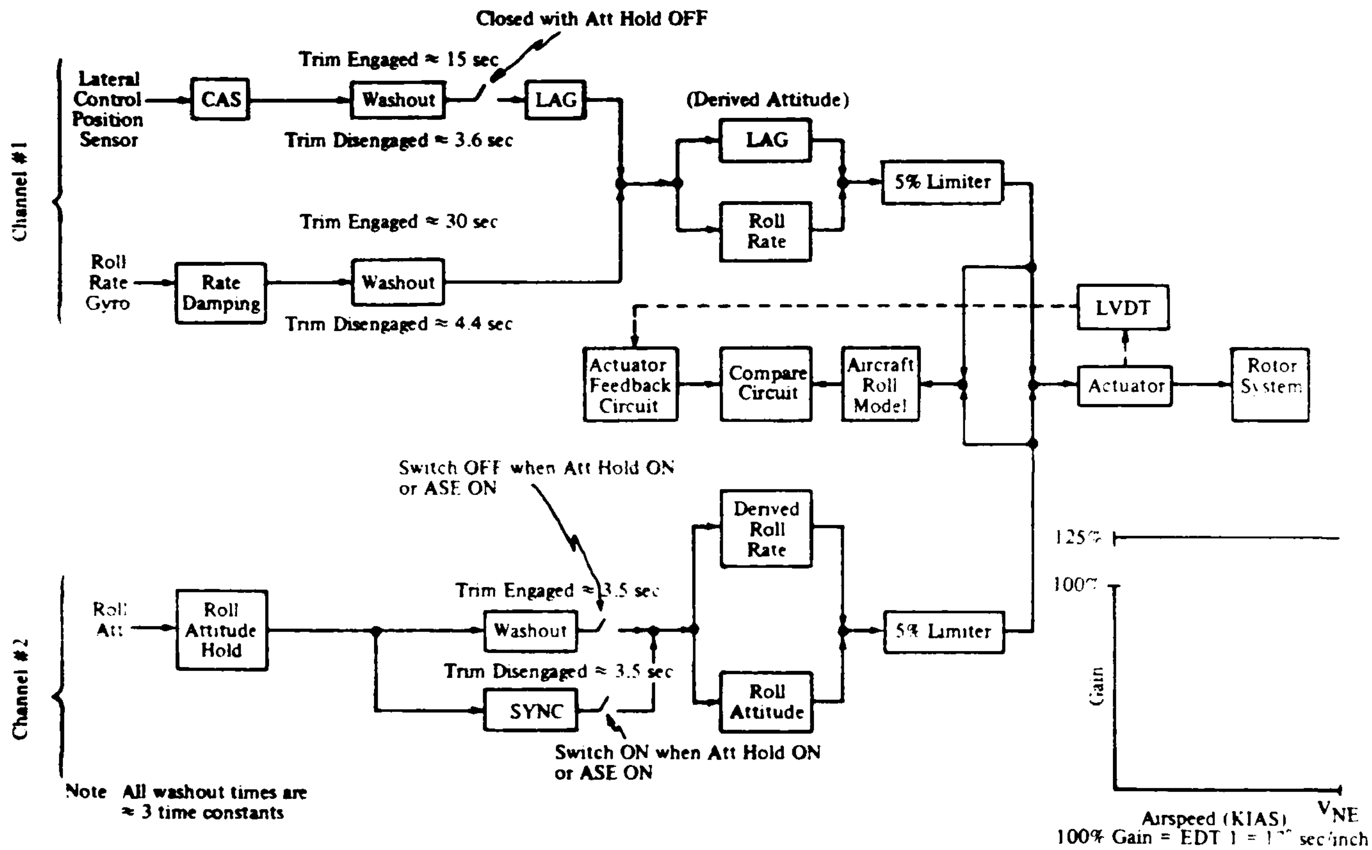


Figure 9. Roll SAS

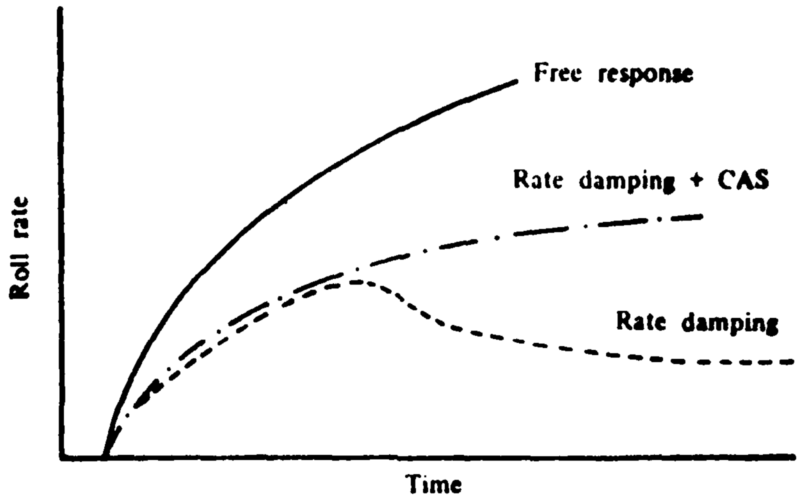
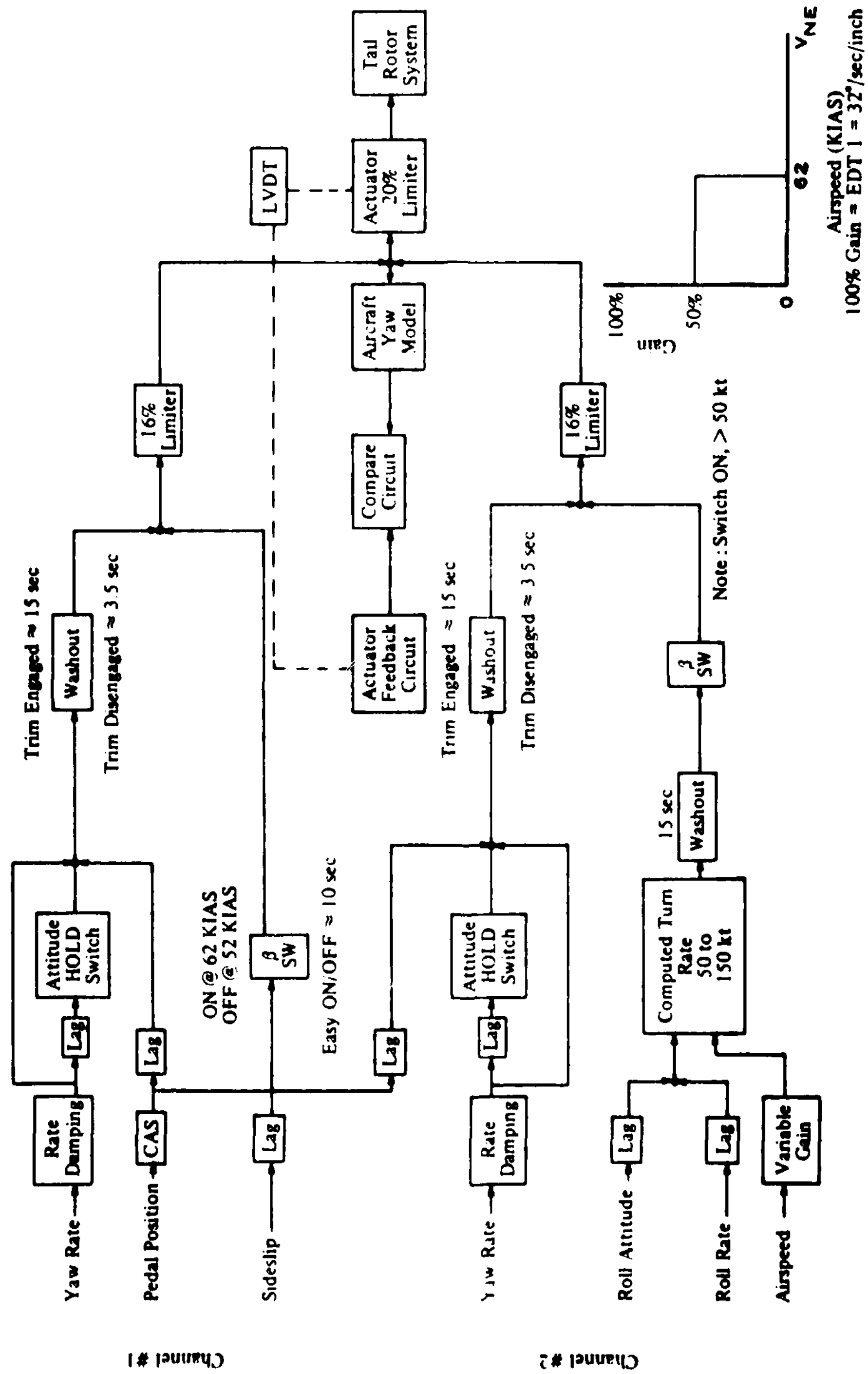


Figure 10. Effects of Roll CAS



Note: All washout time are ≈ 3 time constants

Figure 11. Yaw SAS

which in turn provides automatic turn coordination. This computed trim rate signal is activated at airspeeds over 50 KIAS. In the present system the yaw rate damping function is saturated with an 8 deg/sec yaw rate (change in rate obtained over a one second interval).

Wing Flaps

25. The wing flaps are variably controlled airfoils designed to increase the maneuvering load factor of the aircraft. They are progammed through the control programming unit as a function of collective control position, airspeed, rocket pod position, normal acceleration, and action switch position (fig. 12 and table 1).

Table 1. Wing Flap Position Chart

Case	Crew Station Controls	Other Conditions	Flap Position
1.	Collective stick: Full down (autorotation)	--	-45 deg up (full up)
2.	Collective stick: Greater than 5.2 inches	Airspeed less than 100 knots	+20 deg down (full down)
3.	Collective stick: Greater than 4.0 inches and pitch rate	Airspeed greater than 100 knots	+5 deg down plus inputs to assist pitch rate with return: To 5 deg down
4.	Action switch: Rocket position	Airspeed less than 50 knots, pods 10 deg nose down	-45 deg up
5.	Action switch: Rocket	Airspeed greater than 100 knots.	-12 deg up

Notes: Case 1 overrides cases 4 and 5
Case 4 overrides case 2
Case 5 overrides cases 2 and 3

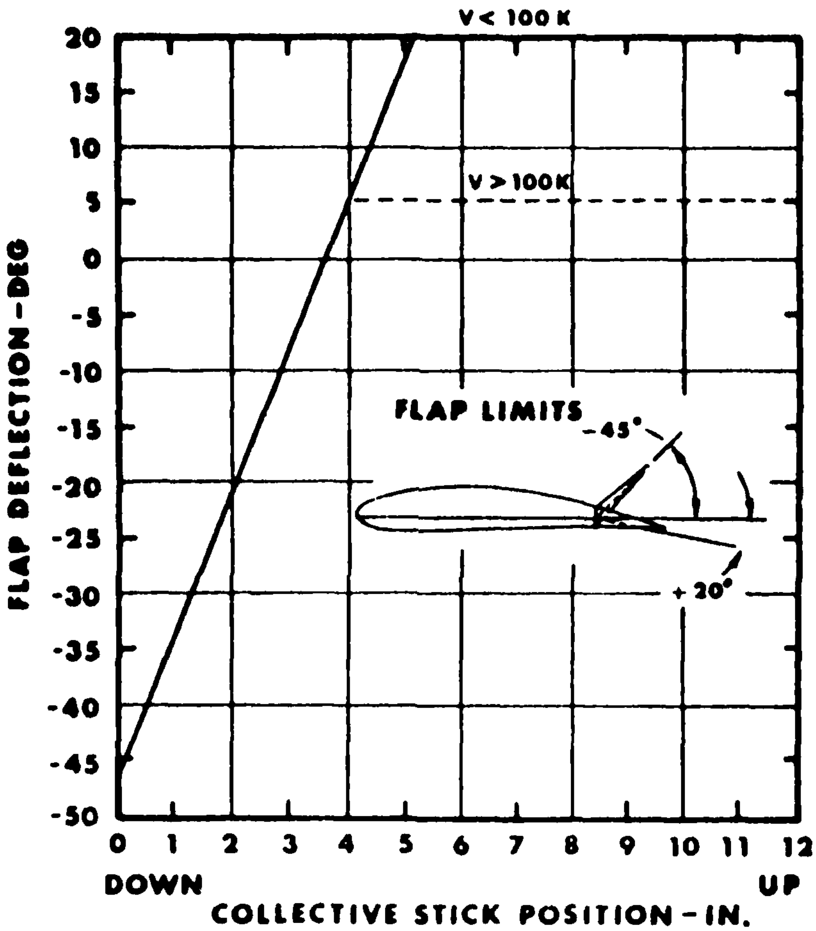


Figure 12. Flap Programming

ENGINE DESCRIPTION

26. The power plant for the YAH-64 helicopter is the General Electric YT700-GE-700 front drive turboshaft engine, rated at 1563 shp (sea level, standard day, uninstalled). The engines are mounted in nacelles on either side of the main transmission. The basic engine consists of four modules: A cold section, a hot section, a power turbine, and an accessory section. Design features of each engine include an axial-centrifugal flow compressor, a through-flow combustor, a two-stage air-cooled high-pressure gas generator turbine, a two-stage uncooled power turbine, and self-contained lubrication and electrical systems. In order to reduce sand and dust erosion, and foreign object damage (FOD), an integral particle separator operates when the engine is running.The YT700-GE-700 engine also incorporates a history recorder which records total engine events. Pertinent engine data are shown below. A more complete engine description is contained in reference 1, appendix A.

Model	YT700-GE-700 (updated)
Type	Turboshaft
Rated power (intermediate) (shp)	1563, sea-level, standard-day, uninstalled
Output speed (Np 100%) (rpm)	20,952
Compressor	5 axial stages, 1 centrifugal stage
Variable geometry	Inlet guide vanes, stages 1 and 2 stator vanes
Combustion chamber	Single annular chamber with axial flow
Gas generator turbine stages	2
Power turbine stages	2
Direction of rotation (aft looking forward)	Clockwise
Weight (dry) (lb)	415
Length (in.)	47
Maximum diameter (in.)	25
Fuel	MIL-T-5624 (JP-4 or JP-5)
Lubricating oil	MIL-L-7808 or MIL-L-23699
Electrical power requirements for history recorder and Np overspeed protection	40W, 115VAC, 400 Hz

Electrical power requirements for anti-ice valve, filter bypass indication, oil filter bypass indication, and magnetic chip detector	1 amp, 28 VDC

BLACK HOLE OCARINA INFRARED SUPPRESSOR

27. The black hole ocarina (BHO) was designed to replace the engine cooling fan used in the phase 1 aircraft. The BHO (fig. 13) consists of finned exhaust pipes attached to the engine outlet and bent outboard to mask hot engine parts. The finned pipes radiate heat which is cooled by rotor downwash in hover and turbulent air flow in forward flight. The engine exhaust plume is cooled by mixing it with engine cooling air and bay cooling air (fig. 13). The exhaust acts as an eductor, creating air flow over the combustion section of the engine providing engine cooling. Fixed louvers on the top and bottom of the aft cowl and a door on the bottom forward cowling provide convective cooling to the engine during shut down. The movable bottom door is closed by engine bleed air during engine operation.

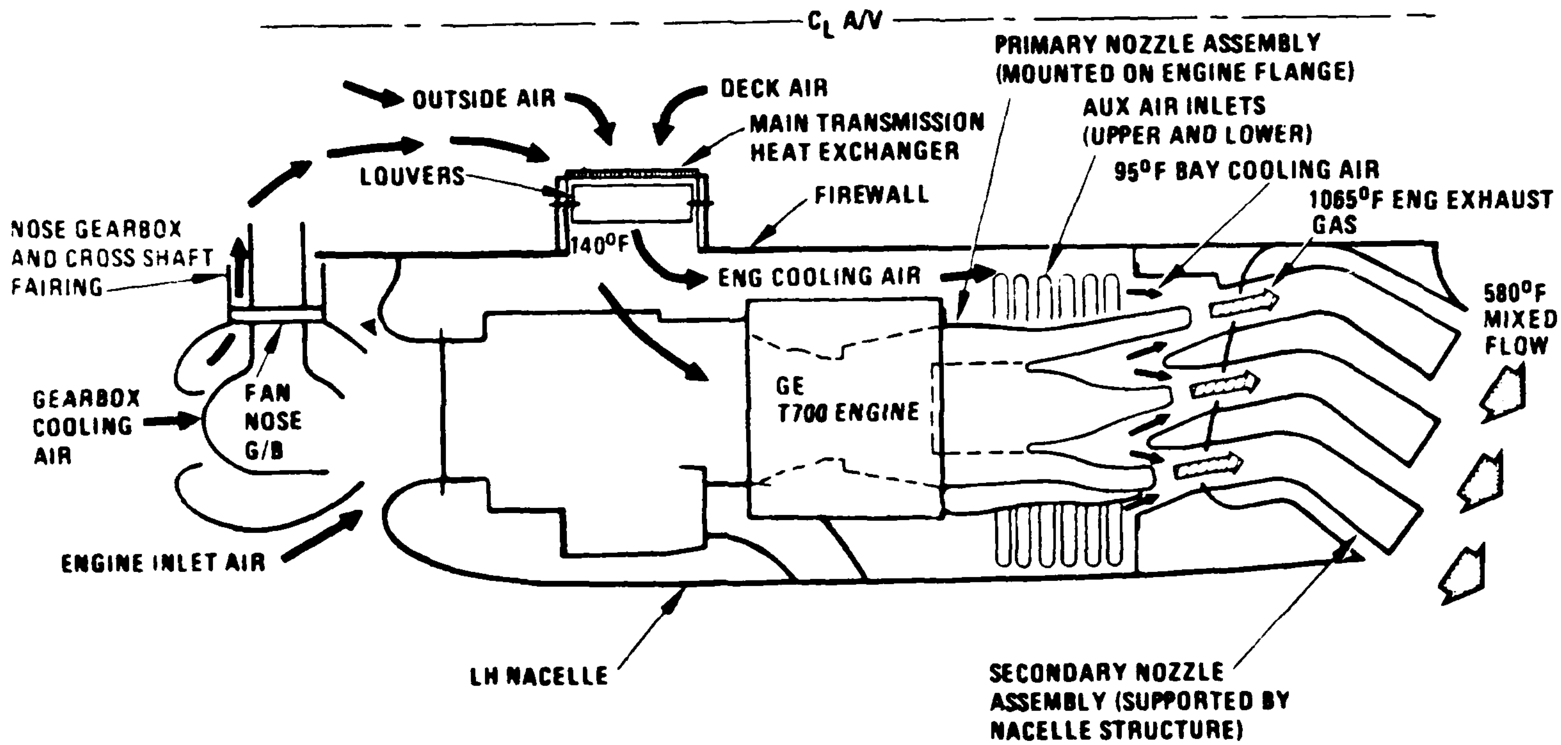


Figure 13. BHO Suppressed Engine Cooling

APPENDIX C. INSTRUMENTATION

The test instrumentation was installed, calibrated, and maintained by HH. A test airspeed boom with swiveling pitot-static head was installed on the nose of both aircraft, and connected to an airspeed indicator and altimeter. Boom airspeed system calibration for aircraft S/N 74-22248 and S/N 74-22249 are shown in figures 1 and 2, respectively. Torquemeter calibrations are shown in figures 3 through 6. Data were measured with calibrated instrumentation and displayed or recorded as indicated below. The parameters were measured on both aircraft unless otherwise noted. Numerous structural measurements which were required for safety of flight are not included in the following list.

Pilot's Panel

- Airspeed (boom system)
- Pressure altitude (boom system)
- Engine output shaft torque[1]
- Engine measured gas temperature ($T_{4.5}$)[1]
- Engine gas generator speed[1]
- Main rotor speed
- Control position indicators
    - Longitudinal
    - Lateral
    - Directional
    - Collective
- Center-of-gravity normal acceleration
- Angle of sideslip
- Rate of climb
- Event switch
- Instrumentation controls and status lights
- Tether cable tension[2]
- Tether cable angle[2]
    - Longitudinal
    - Lateral

Copilot/Gunner's Panel

- Airspeed (boom system)
- Pressure altitude (boom system)
- Engine output shaft torque[1]
- Engine measured gas temperature ($T_{4.5}$)[1]
- Main rotor speed
- Center-of-gravity normal acceleration
- Angle of sideslip
- Fuel used (totalizer)
- Outside air temperature

[1] Both engines
[2] S/N 74-22249 only

Time code display
Event switch
Instrumentation controls and status lights

Magnetic Tape

- Time of day
- Pilot event
- Copilot event
- Control position indicators
  - Longitudinal
  - Lateral
  - Directional
  - Collective
- Control force
  - Longitudinal
  - Lateral
  - Directional
  - Collective
- SAS actuator position
  - Pitch
  - Roll
  - Yaw
- ASE wing flap position
- Aircraft attitude, rate, and angular acceleration
  - Pitch
  - Roll
  - Yaw
- Angle of attack
- Angle of sideslip
- Center-of-gravity acceleration
  - Vertical
  - Lateral
  - Longitudinal
- Main rotor speed
- Main rotor shaft torque[3]
- Main rotor azimuth index[3]
- Main rotor flapping angle[3]
- Main rotor feathering angle[3]
- Main rotor lead-lag angle[3]
- Tail rotor shaft torque
- Tail rotor teeter angle
- Airspeed (boom system)
- Static pressure (boom system)
- Total air temperature
- Engine output shaft torque[1]
- Engine fuel used[1]
- Engine gas generator speed[1]

[1] Both engines
[2] S/N 74-22249 only
[3] S/N 74-22248 only

Engine power turbine speed[1]
Engine measured gas generator speed[1]
Engine fuel flow[1]
Tether cable tension[2]
Tether cable angle[2]
    Longitudinal
    Lateral
Vibration acceleration (3 axes)
    Pilot seat
    Copilot/gunner seat
    Aircraft center-of-gravity

[1] Both engines
[2] S/N 74-22249 only
[3] S/N 74-22248 only

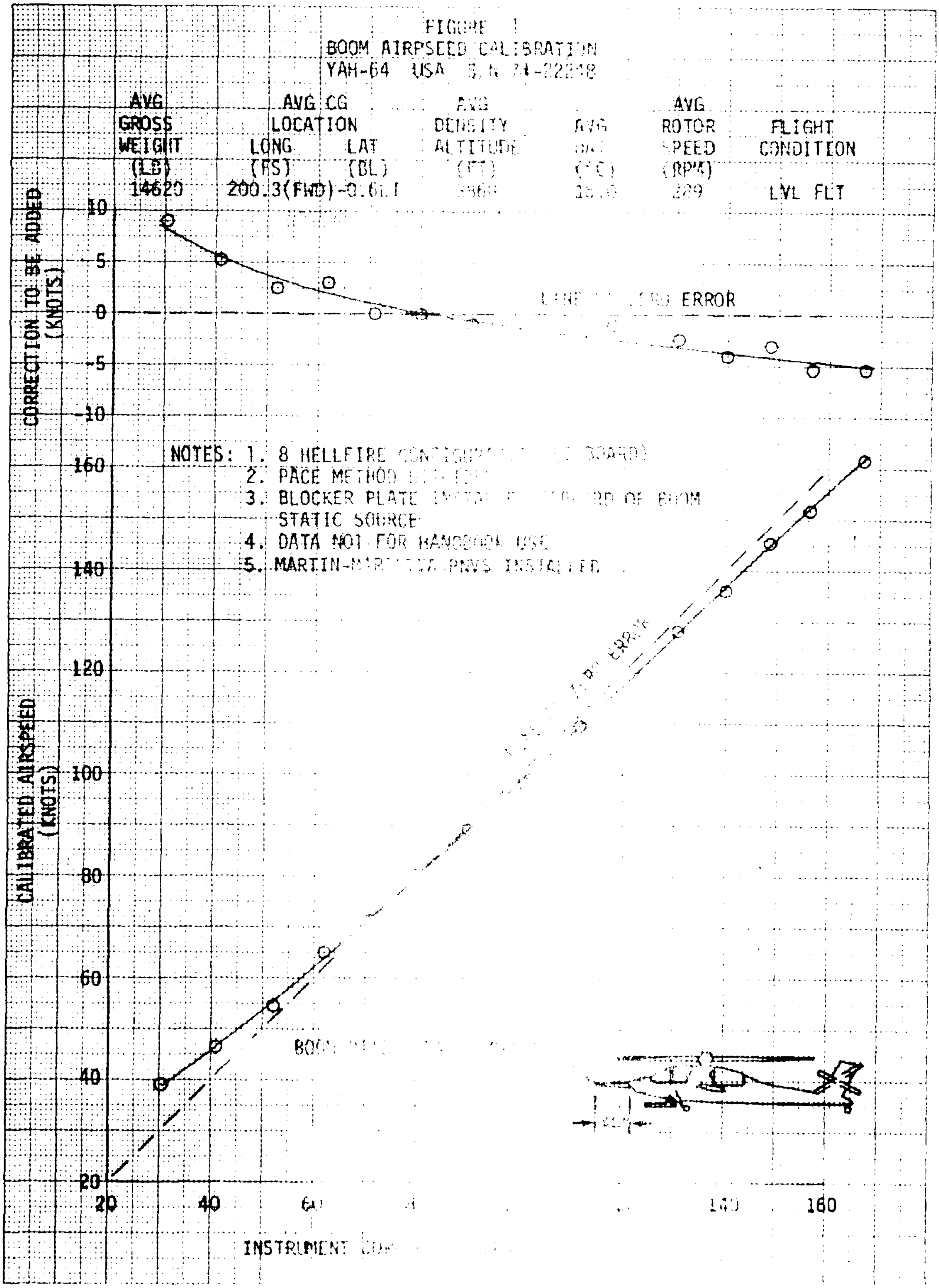


FIGURE 1
BOOM AIRPSEED CALIBRATION
YAH-64 USA
AVG GROSS WEIGHT (LB) 14620
AVG CG LOCATION LONG (FS) 200.3(FWD) LAT (BL)
AVG DENSITY ALTITUDE (FT)
AVG ROTOR SPEED (RPM) 289
FLIGHT CONDITION LVL FLT
CORRECTION TO BE ADDED (KNOTS)
10
5
0
-5
-10
ERROR
NOTES: 1. 8 HELLFIRE
2. PACE METHOD
3. BLOCKER PLATE
STATIC SOURCE
4. DATA NOT FOR
5. MARTIN-
CALIBRATED AIRSPEED (KNOTS)
160
140
120
100
80
60
40
20
20
40
60
140
160
INSTRUMENT

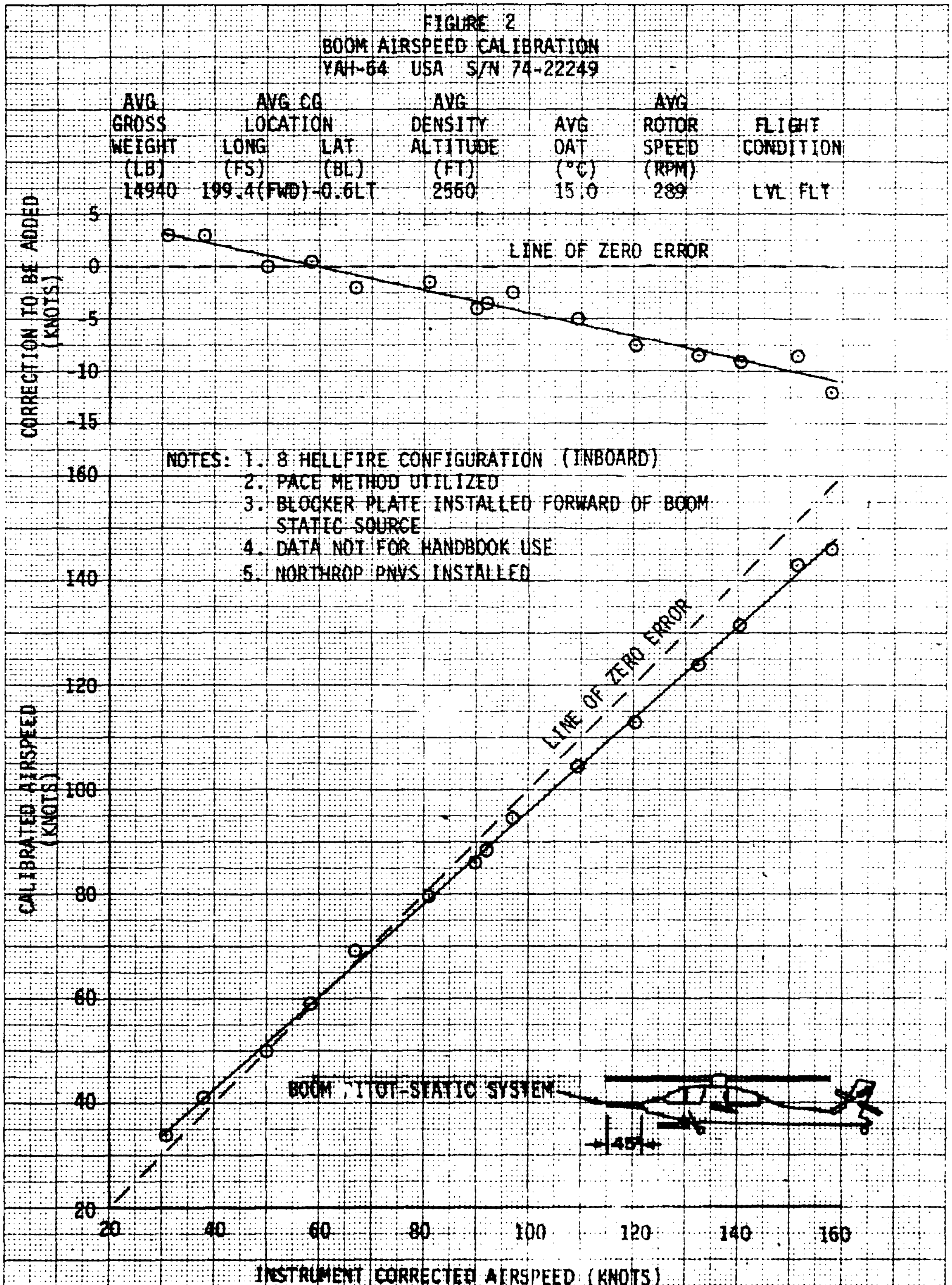


FIGURE 2
BOOM AIRSPEED CALIBRATION
YAH-64 USA S/N 74-22249
AVG GROSS WEIGHT (LB) 14940
AVG CG LOCATION LONG (FS) 199.4(FWD)
LAT (BL) 0.6LT
AVG DENSITY ALTITUDE (FT) 2560
AVG OAT (°C) 15.0
AVG ROTOR SPEED (RPM) 289
FLIGHT CONDITION LVL FLT
CORRECTION TO BE ADDED (KNOTS)
5
0
-5
-10
-15
LINE OF ZERO ERROR
NOTES: 1. 8 HELLFIRE CONFIGURATION (INBOARD)
2. PACE METHOD UTILIZED
3. BLOCKER PLATE INSTALLED FORWARD OF BOOM STATIC SOURCE
4. DATA NOT FOR HANDBOOK USE
5. NORTHROP PNVS INSTALLED
CALIBRATED AIRSPEED (KNOTS)
160
140
120
100
80
60
40
20
LINE OF ZERO ERROR
BOOM PITOT-STATIC SYSTEM
45°
20
40
60
80
100
120
140
160
INSTRUMENT CORRECTED AIRSPEED (KNOTS)

FIGURE 3
ENGINE TORQUE INDICATING SYSTEM CALIBRATION
YT700-GE-700 ENGINE S/N 207237R
CALIBRATION DATE 11 MAY 1979

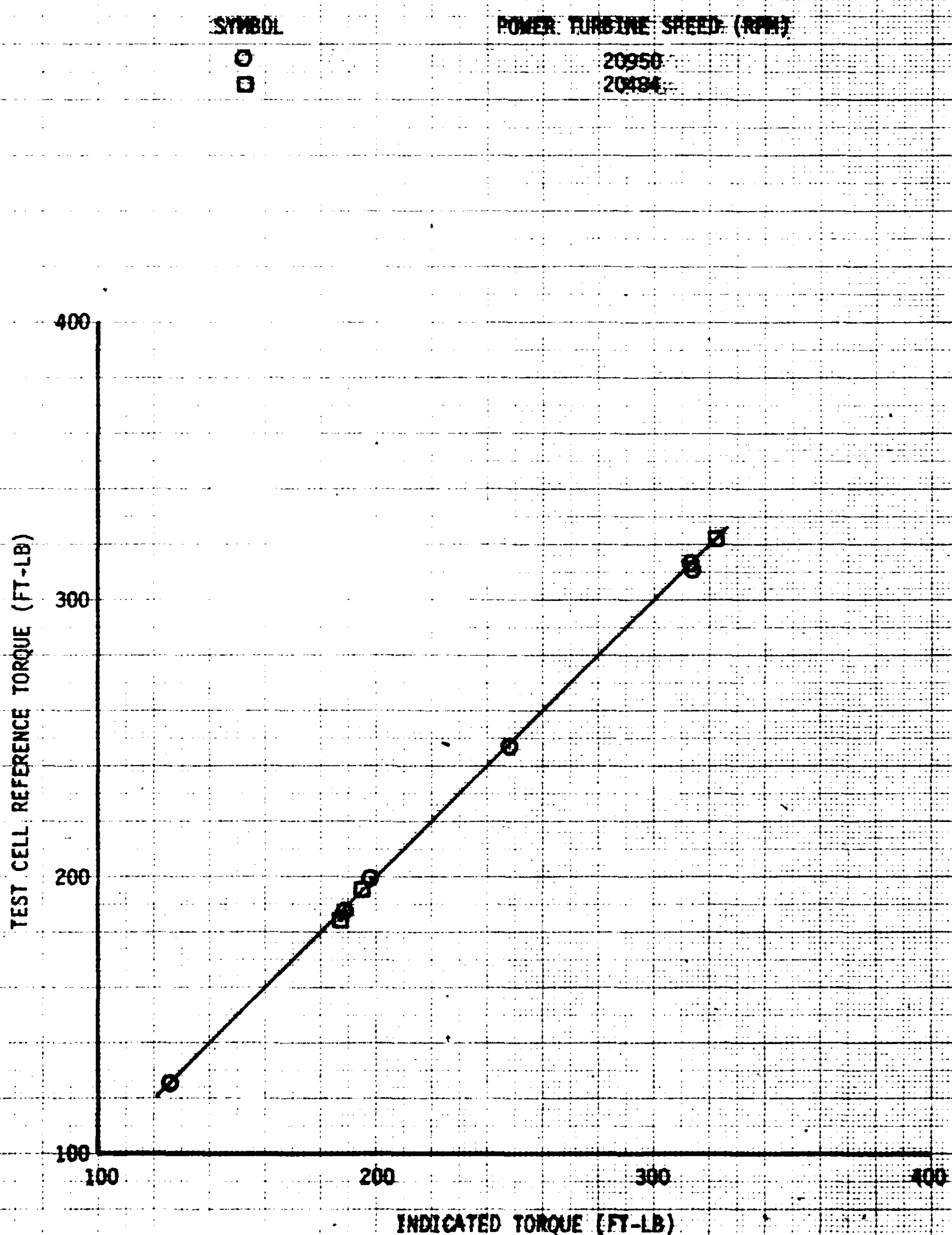


FIGURE 4
ENGINE TORQUE INDICATING SYSTEM CALIBRATION
YT700-GE-700 ENGINE S/N 207239R
CALIBRATION DATE 12 MAY 1979

SYMBOL	POWER TURBINE SPEED (RPM)
O	20960
□	20497

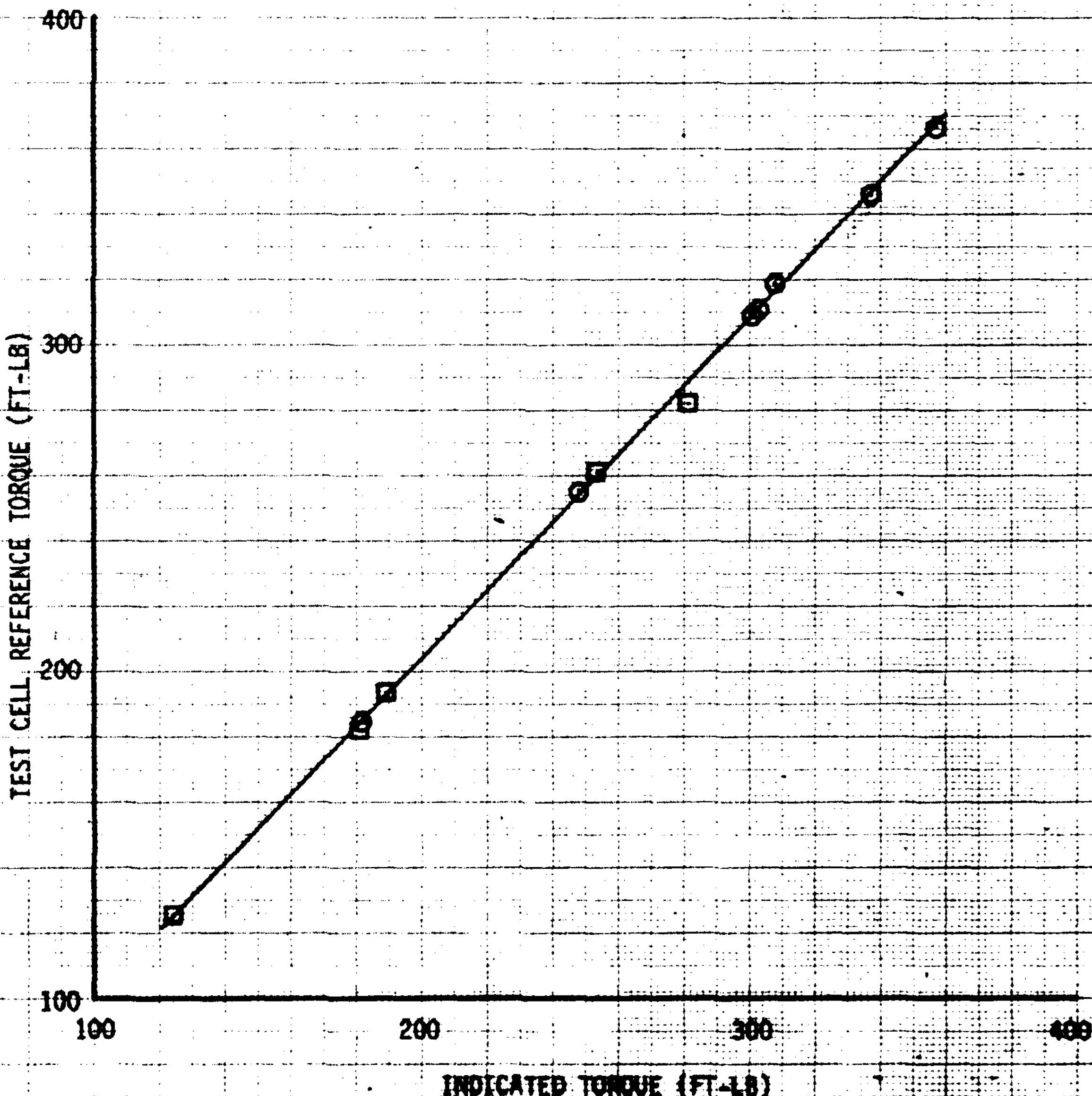


FIGURE 5
ENGINE TORQUE INDICATING SYSTEM CALIBRATION
YT700-GE-700 ENGINE S/N 207245R
CALIBRATION DATE 17 FEBRUARY 1979

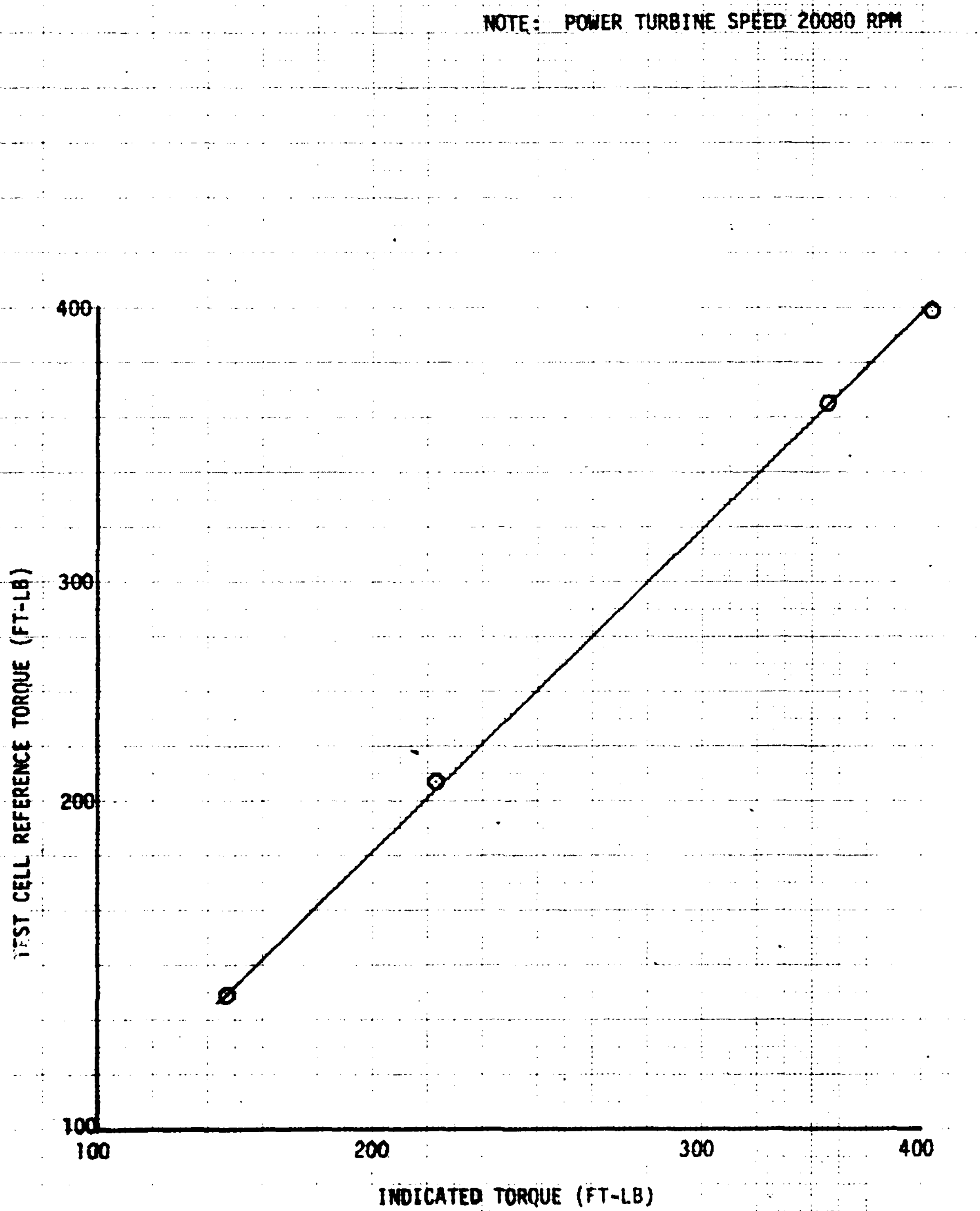
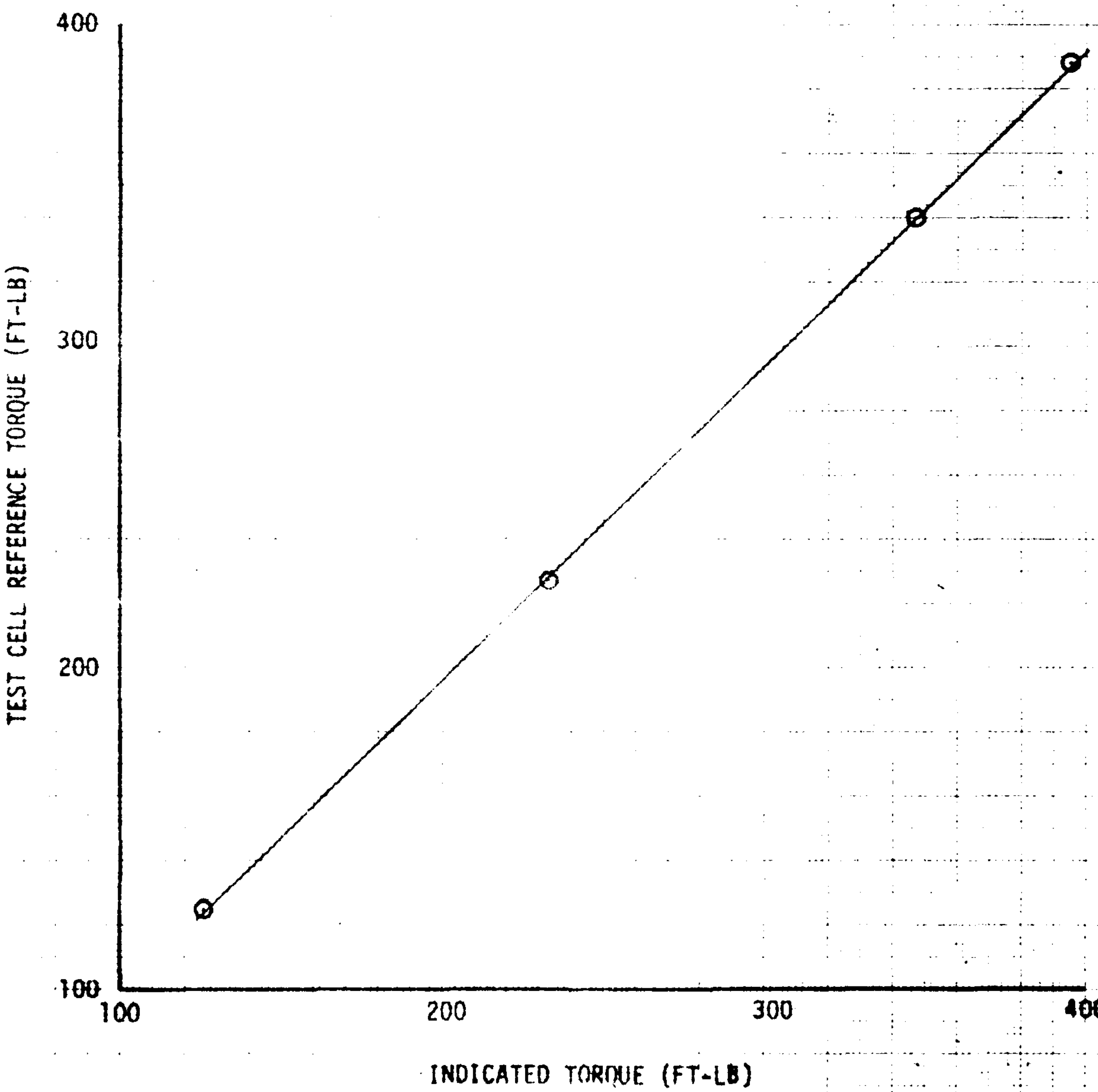


FIGURE 6
ENGINE TORQUE INDICATING SYSTEM CALIBRATION
YT700-GE-700 ENGINE S/N 207248R
CALIBRATION DATE 26 MARCH 1979

NOTE: POWER TURBINE SPEED 20100 RPM



APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

TEST TECHNIQUES

1. Conventional test techniques were used in both the performance and handling qualities testing. The basic techniques employed for each test are described in the Results and Discussion section of this report. Detailed descriptions of all test techniques are contained in references 7 and 8, appendix A.

DATA ANALYSIS METHODS

2. The helicopter performance test data were generalized by use of non-dimensional coefficients and were such that the effects of compressibility and blade stall were not separated and defined. The following non-dimensional coefficients were used to generalize the hover, level flight, and climb test results obtained during this flight test program.

a. Coefficient of power (C_P):

$$C_P = \frac{SHP(550)}{\rho A(\Omega R)^3} \qquad (1)$$

b. Coefficient of thrust (C_T):

$$C_T = \frac{\text{Thrust}}{\rho A(\Omega R)^2} \qquad (2)$$

c. Advance ratio (μ):

$$\mu = \frac{1.6878\ V_T}{\Omega R} \qquad (3)$$

d. Advancing tip Mach number (M_{tip}):

$$M_{tip} = \frac{1.6878\ V_T + (\Omega R)}{a} \qquad (4)$$

Where:

SHP = Engine output shaft horsepower (both engines)
550 = Conversion factor (ft lb/sec/shp)
ρ = Air density (slug/ft^3)
A = Main rotor disc area (ft^2)
Ω = Main rotor angular velocity (radian/sec)
R = Main rotor radius (ft)

Thrust = Gross weight (lb) during free flight in which there is no acceleration or velocity component in the vertical direction. Tether load must be added in the case of tethered hover.

1.6878 = Conversion factor (ft/sec/kt)
V_T = True airspeed (kt)
a = Speed of sound (ft/sec) = $1116.45\sqrt{\theta}$

Shaft Horsepower Required

3. Engine output shaft torque was determined by the use of the engine torquemeter. The torquemeter was calibrated in a test cell by the engine manufacturer (figs. 3 through 6, app C). The outputs from the engine torquemeters were recorded on the on-board data recording system. The output shp was determined from the engine output shaft torque and rotational speed by the following equation:

$$SHP = \frac{2\pi \times N_P \times Q}{33{,}000} \qquad (5)$$

Where:

N_P = Engine output shaft rotational speed (rpm)
Q = Engine output shaft torque (ft-lb)
33,000 = Conversion factor (ft-lb/min/shp)

Hover Performance

4. Hover performance was obtained OGE by the tethered hover technique. The hover test was conducted in winds of less than 5 knots. Tethered hover consisted of restraining the helicopter to the ground by a cable in series with a load cell. An increase in cable tension, measured by the load cell, had the same effect on hover performance as increasing gross weight. Atmospheric pressure, temperature, and wind velocity were recorded from a ground weather station. All hover data were reduced to non-dimensional parameters of C_P and C_T (equations 1 and 2).

Tail Rotor Performance

5. During hover performance tests, tail rotor performance parameters were also recorded. Terms in equations 1 and 2, which apply to the main rotor, were replaced by tail rotor parameters for non-dimensionalized tail rotor performance. The redefined terms are as follows:

SHP = Tail rotor shaft horsepower (SHP_{TR})
A = Tail rotor disc area (ft^2)
Ω = Tail rotor angular velocity (radian/sec)
R = Tail rotor radius (ft)
Thrust = Tail rotor thrust (lb)

Tail rotor shp was determined from the following equation:

$$SHP_{TR} = \frac{2\pi \times N_R \times 4.8824 \times Q_{TR}}{33{,}000} \qquad (6)$$

Where:

N_R = Rotational speed of the main rotor (revolutions/minute)
Q_{TR} = Tail rotor torque (ft-lb)
4.8824 = Gear ratio between tail and main rotors

6. The tail rotor thrust for hover was determined by making two assumptions. These assumptions were necessary since sufficient information was not available and tail rotor thrust could not be measured directly during the evaluation. The first assumption was that all directional moments to react main rotor torque would be generated by the antitorque tail rotor. This assumption neglected any possible restoring moments that could be derived from rotor downwash and recirculating airflow over the fuselage, tail boom section, and empennage. The second assumption was that the temperature of the airflow passing through the tail rotor was not significantly influenced by the engine exhaust gasses. Tail rotor thrust was determined from the following equation:

$$\text{Thrust}_{TR} = \frac{Q_{MR}}{l_t} \qquad (7)$$

Where:

Q_{MR} = Main rotor shaft torque (ft-lb) (Calculated from total engine torque less accessory losses less tail rotor torque)
l_t = Perpendiculat distance between center lines of main and tail rotor shafts = 28.49 feet

Generalized Climb and Descent Performance

7. A series of sawtooth climbs and partial power descents were flown to determine generalized climb and descent performance. The rates of climb and descent (dH_p/dt) were determined from the rate of change of boom pressure altitude (H_p) with time, corrected for instrument error, static position error, and altimeter error caused by nonstandard temperature using the following equation:

$$R/C_T = \left(\frac{dH_p}{dt}\right)\left(\frac{T_t}{T_s}\right) \qquad (8)$$

Where:

$\frac{dH_p}{dt}$ = Slope of pressure altitude versus time curve at a given altitude (ft/min)

T_t = Test ambient air temperature at the pressure altitude at which the slope is taken (°K)
T_S = Standard ambient air temperature at the pressure altitude at which the slope is taken (°K)

8. Climb and descent performance were reduced to generalized parameters to provide a means for computing performance at any specific climb or descent con-

ditions. The following parameters were used to generalize the climb and descent data:

Generalized power, variation from level flight:

$$\Delta C_{P_{GEN}} = \frac{C_{P_c} - C_{P_l}}{0.707\, C_T^{\,1.5}} \tag{9}$$

Vertical velocity ratio (VVR):

$$\bar{V}_H = \frac{V_v}{(\Omega R)\sqrt{C_T/2}} \tag{10}$$

Forward velocity ratio (FVR):

$$\bar{V}_V = \frac{V_h}{(\Omega R)\sqrt{C_T/2}} \tag{11}$$

Where:

C_{P_c} = Climb power coefficient

C_{P_l} = Level flight power coefficient

V_v = Vertical velocity (ft/sec) = $\dfrac{R/C}{60}$

V_h = Forward velocity (ft/sec) = $\sqrt{(V_T \times 1.6878)^2 - V_v^2}$

9. Climb power required for any condition can then be computed from these equations by determining $\Delta C_{P_{GEN}}$ as a function of VVR and FVR required for the specific condition. The level flight power coefficient (C_{P_l}) was obtained from the non-dimensional level flight performance curves.

$$C_{P_c} = \Delta C_{P_{GEN}} (.707 C_T^{\,1.5}) + C_{P_l} \tag{12}$$

Level Flight Performance

10. Level flight speed-power performance was determined by using equations 1, 2, and 3. Each speed-power was flown at a predetermined C_T with rotor speed held constant. To maintain the ratio of gross weight to air density ratio (W/σ) constant, altitude was increased as fuel was consumed.

11. Test-day level flight power was corrected to standard-day conditions by assuming that the test-day dimensionless parameters C_{P_S}, C_{T_S}, and μ_S are identical to C_{P_t}, C_{T_t}, and μ_T, respectively.

From equation 1, the following relationship can be derived:

$$SHP_S = SHP_t \left(\frac{\rho_S}{\rho_t}\right) \tag{13}$$

Where:

t = Test day
s = Standard day

12. Test specific range was calculated using level flight performance curves and the measured fuel flow.

$$NAMPP = \frac{V_T}{W_f} \tag{14}$$

Where:

NAMPP = Nautical air miles per pound of fuel
V_T = True airspeed (kt)
W_f = Fuel flow (lb/hr)

13. Changes in the equivalent flat plate area (Δf_e) for various aircraft configurations were calculated by the following equation:

$$\Delta f_e = \frac{2(\Delta C_p)A}{\mu^3} \tag{15}$$

Where:

Δf_e = Change in flat plate area (ft^2)
ΔC_P = Change in coefficient of power at constant C_T and μ
A = Main rotor disc area (ft^2)

A rotor efficiency of 100 percent was used for all equivalent flat plate area calculations.

Drive Train and Accessory Losses

14. Main transmission and drive train power losses were determined by comparing the total engine shaft horsepower to the total rotor horsepower, as follows:

Where : $\Delta HP = FSHP - RHP$ (16)

FSHP = Total engine shaft horsepower (both)

RHP = Main rotor horsepower plus tail rotor horsepower

Handling Qualities

15. Stability and control data were collected and evaluated using standard test methods as described in reference 8, appendix A. Definitions of deficiencies and shortcomings are as stipulated in Army Regulation 310-25.

Dynamic Response

16. The dynamic response characteristics of the aircraft were evaluated to determine the damping ratios (ζ). Damping ratios were determined for all conditions tested using the logarithmic decrement method. The logarithmic decrement is defined as the natural logarithm of the ratio of any two successive peaks (fig. 1).

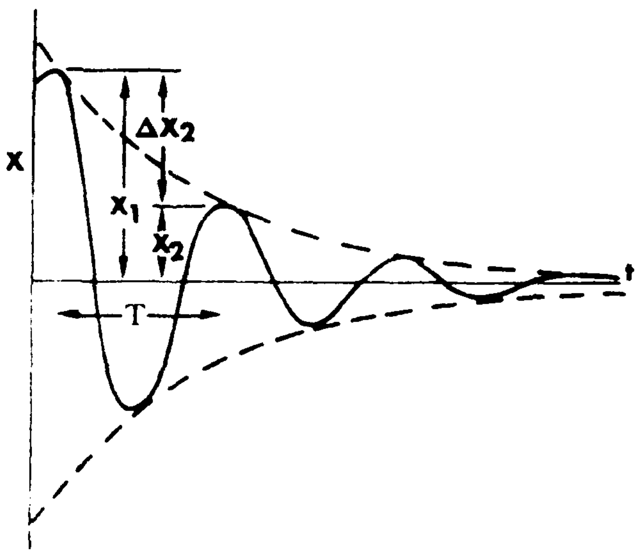


Figure 1. Rate of Decay of Oscillation Measured by the Logarithmic Decrement

The logarithmic decrement of δ is mathematically expressed as:

$$\delta = \ln \frac{X_1}{X_2} = \ln \frac{e^{-\zeta\omega_n T_1}}{e^{-\zeta\omega_n (T_1 + \tau)}} = \ln e^{\zeta\omega_n \tau} = \zeta\omega_n \tau \qquad (17)$$

Since the period of the damped oscillation is equal to :

$$\tau = 2\pi/\omega_n\sqrt{1-\zeta^2} \tag{18}$$

The decrement can be rewritten as :

$$\delta = \ln\frac{x_1}{x_2} = 2\pi\zeta/\sqrt{1-\zeta^2} \tag{19}$$

As seen in figure 2 for small values of ζ

$$\delta < 3,\ \zeta \cong \ln\frac{x_1}{x_2}\ /2\pi \tag{20}$$

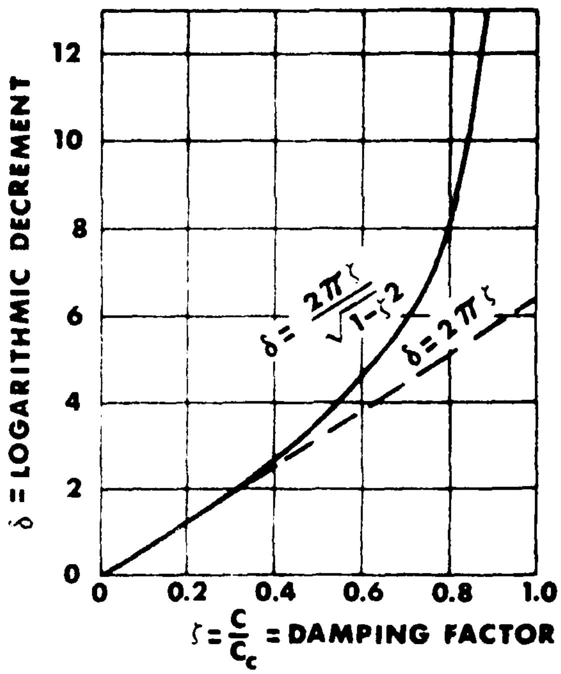


Figure 2. Logarithmic Decrements of Function of ζ

The frequency is defined as $\omega = 2\pi/\tau$ rad/sec; the natural frequency is defined as:

$$\omega_n = 2\pi/\tau\sqrt{1-\zeta^2} \tag{21}$$

Vibrations

17. The PCM vibration data were reduced by means of a fast Fourier transform from the analog flight tape. Vibration levels, representing peak amplitudes, were extracted from this analysis at selected harmonics of the main rotor frequency. The Vibration Rating Scale, presented in figure 3, was used to augment crew comments on aircraft vibration levels.

Engine Performance

18. The YAH-64 S/N 74-22248 was equipped with YT 700-GE-700 engines S/N 20745R and S/N 20748R, installed in the left and right engine nacelles respectively. Data for the engine torque, fuel flow, measured gas temperature, and gas producer speed were otained from the engine acceptance test run. The YAH-64 S/N 74-22249 was equipped with calibrated YT 700-GE-700 engine S/N 207239R and S/N 207237R installed in the left and right engine nacelles respectively. Data for engine torque, fuel flow, measured gas temperature, and gas producer speed were obtained from a special engine test cell calibration. The engine performance data obtained during level flight and hover testings were compared to the calibrations and acceptance data to verify engine performance.

Airspeed Calibration

19. *The boom pitot static system was calibrated by using the pace aircraft method* to determine the airspeed position error. Calibrated airspeed (V_{cal}) was obtained by correcting indicated airspeed (V_i) for instrument error (ΔV_{ic}) and position error (ΔV_{pc}).

$$V_{cal} = V_i + \Delta V_{ic} + \Delta V_{pc} \tag{22}$$

20. Equivalent airspeed (knots) was used to reduce the flight test data, as it is a direct measure of the free stream dynamic pressure (q).

$$V_e = V_{cal} - \Delta V_c \tag{23}$$

Where:

ΔV_c is the compressibility correction, $q = 0.00339\ V_e^2$

21. True airspeed (V_t) was calculated from the equivalent airspeed and density ratio.

$$V_t = \frac{V_e}{\sqrt{\sigma}} \tag{24}$$

Where:

σ = Density ratio $(\frac{\rho}{\rho o})$ where ρo is the density at sea level on a standard day.

DEGREE OF VIBRATION	DESCRIPTION[1]	PILOT RATING
No vibration		0
Slight	Not apparent to experienced aircrew fully occupied by their tasks, but noticeable if their attention is directed to it or if not otherwise occupied.	1, 2, 3
Moderate	Experienced aircrew are aware of the vibration but it does not affect their work, at least over a short period.	4, 5, 6
Severe	Vibration is immediately apparent to experienced aircrew even when fully occupied. Performance of primary task is affected or tasks can only be done with difficulty.	7, 8, 9
Intolerable	Sole preoccupation of aircrew is to reduce vibration level.	10

[1] Based upon the Subjective Vibration Assessment Scale developed by the Aeroplane and Armament Experimental Establishment, Boscombe Down, England.

Figure 3. Vibration Rating Scale

Weight and Balance

22. Prior to testing, the aircraft gross weight and longitudinal and lateral cg were determined by using calibrated scales. The longitudinal cg was calculated by a summation of moments about a reference datum line (FS 0.0). The aircraft was weighed empty in the clean configuration, which included instrumentation minus all munitions and fuel. The basic aircraft weight was 13003 pounds with a longitudinal cg location of 208.7 inches for aircraft S/N 74-22248 and 12940 pounds and 209.3 inches for aircraft S/N 74-22249.

Handling Qualities Rating Scale

23. The Handling Qualities Rating Scale (HQRS) presented in figure 4 was used to augment pilot comments relative to handling qualities and workload.

Flight Control Rigging Check

24. A flight control rigging check was performed in accordance with procedures outlined in HH Engineering Test Procedure (ETP) 7-211511000 (Main Rotor), ETP 7-11524000 (Tail Rotor), and ETP 7-115130000 (Wing Flaps) dated July 1978. All control checks were demonstrated within the prescribed limits except for the following two conditions. The wing flap rigging on YAH-64 S/N 74-22249 was determined to meet the requirements of the ETP with the exception that the "UP" position was measured as being 37 degrees from the trail position, which is 5 degrees out of tolerance. The main rotor rigging on YAH-64 on S/N 74-22249 was determined to meet the requirements of the ETP except items 15 and 16 of table 4 differed by 36 minutes which is 6 minutes out of tolerance. The blade angles and flap position angles were measured with respect to the aircraft axis and are as presented in tables 1 through 8.

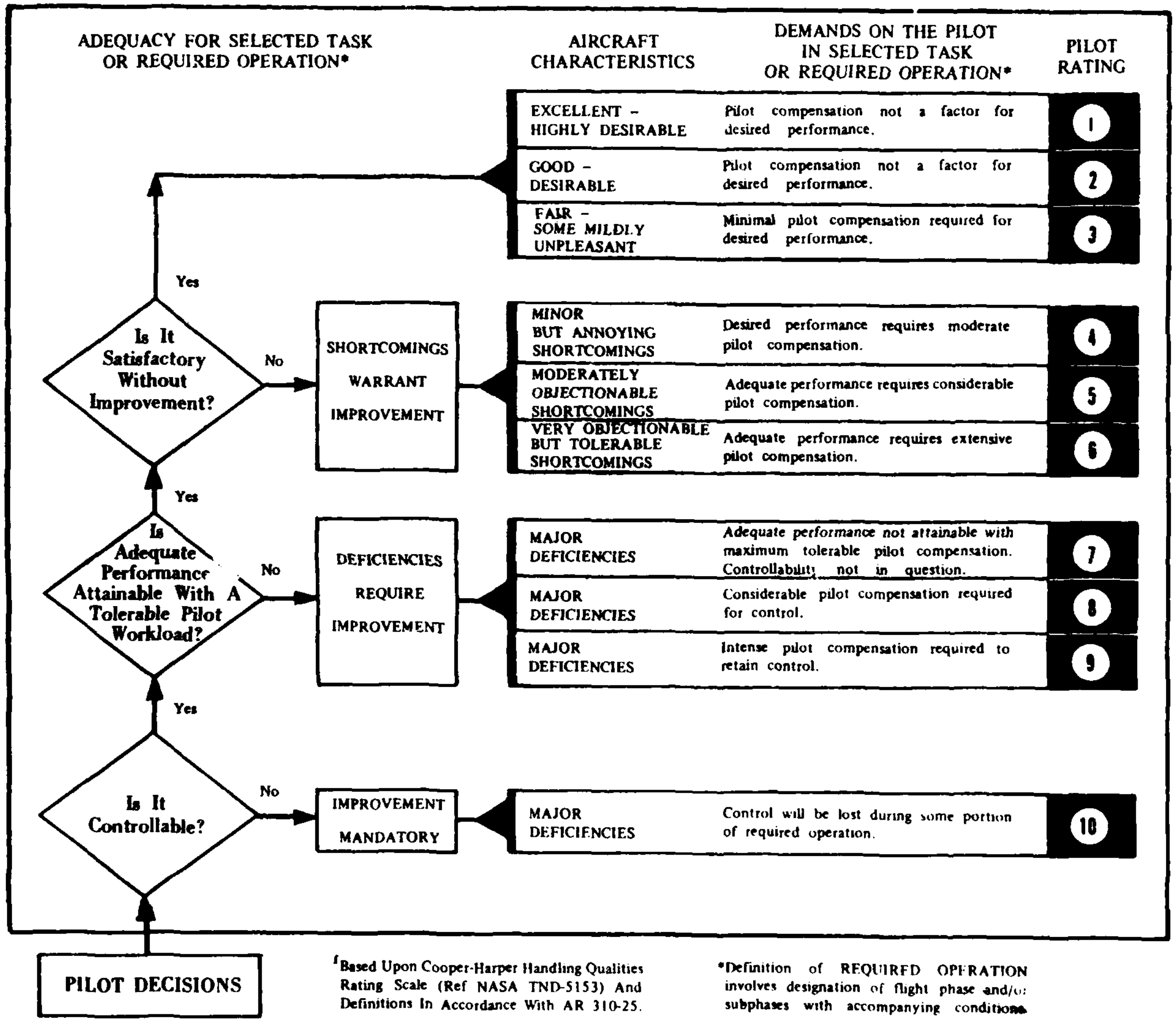


Figure 4. Handling Qualities Rating Scale

Table 1. Angle Measurements - Pilot's Collective and Cyclic Controls
YAH-64 S/N 74-22248

Blade Azimuth Position (deg)	Item	Rig Pins			Stick Position			Measured Clinometer Angle	Leading Edge Up or Down
		Collective	Longitudinal Cyclic	Lateral Cyclic	Collective	Longitudinal	Lateral		
$\psi = 90$	1	In	In	In	Rig	Rig	Rig	51 min	Up
	2	In	Out	In	Rig	Fwd	Rig	20 deg 20 min	Down
	3	In	Out	In	Rig	Aft	Rig	10 deg 58 min	Up
	4	In	In	In	Rig	Rig	Rig	28 min	Up
	5	Out	In	In	Up	Rig	Rig	10 deg 20 min	Up
	6	Out	In	In	Down	Rig	Rig	8 deg 55 min	Down
$\psi = 90$	7	In	In	In	Rig	Rig	Rig	17 min	Up
$\psi = 270$	8	In	In	In	Rig	Rig	Rig	38 min	Up
	9	In	Out	In	Rig	Fwd	Rig	22 deg 38 min	Up
	10	In	Out	In	Rig	Aft	Rig	9 deg 15 min	Down
$\psi = 270$	11	In	In	In	Rig	Rig	Rig	44 min	Up
$\psi = 0$	12	In	In	In	Rig	Rig	Rig	20 min	Up
	13	In	In	Out	Rig	Rig	Left	11 deg 36 min	Up
	14	In	In	Out	Rig	Rig	Right	7 deg 22 min	Down
$\psi = 0$	15	In	In	In	Rig	Rig	Rig	20 min	Up
$\psi = 180$	16	In	In	In	Rig	Rig	Rig	44 min	Up
	17	In	In	Out	Rig	Rig	Left	10 deg 29 min	Down
	18	In	In	Out	Rig	Rig	Right	8 deg 52 min	Up
$\psi = 180$	19	In	In	In	Rig	Rig	Rig	54 min	Up

Table 2. Tail Rotor Angle Measurements
YAH-64 S/N 74-22248

Inboard Tail Rotor

Blade Position	Pedal Position	Blade Angle (deg)	Item
Blade 4 aft	Left forward	34 deg 31 min	1
	Right forward	12 deg 34 min	2
Blade 4 forward	Left forward	34 deg 6 min	3
	Right forward	15 deg 0 min	4
Blade 2 aft	Left forward	34 deg 10 min	5
	Right forward	13 deg 0 min	6
Blade 2 forward	Left forward	33 deg 58 min	7
	Right forward	13 deg 25 min	8

Table 3. Tail Rotor Angle Measurements
YAH-64 S/N 74-22248

Outboard Tail Rotor

Blade Position	Pedal Position	Blade Angle (deg)	Item
Blade 1 aft	Left forward	13 deg 5 min	1
	Right forward	33 deg 8 min	2
Blade 1 forward	Left forward	33 deg 57 min	3
	Right forward	13 deg 33 min	4
Blade 3 aft	Left forward	33 deg 28 min	5
	Right forward	12 deg 50 min	6
Blade 3 forward	Left forward	34 deg 0 min	7
	Right forward	13 deg 14 min	8

Table 4. Wing Flap
YAH-64 S/N 74-22248

Flap Position	Flap Angle From Trail Position
UP	45 deg
DOWN	20 deg

Table 5. Angle Measurements - Pilot's Collective and Cyclic Controls
YAH-64 S/N 74-22249

Blade Azimuth Position (deg)	Item	Collective	Rig Pins Longitudinal Cyclic	Lateral Cyclic	Collective	Stick Position Longitudinal	Lateral	Measured Clinometer Angle	Leading Edge Up or Down
$\psi = 90$	1	In	In	In	Rig	Rig	Rig	14 min	Down
	2	In	Out	In	Rig	Fwd	Rig	21 deg 52 min	Down
	3	In	Out	In	Rig	Aft	Rig	10 deg 23 min	Up
	4	In	In	In	Rig	Rig	Rig	15 min	Down
	5	Out	In	In	Up	Rig	Rig	9 deg	Up
	6	Out	In	In	Down	Rig	Rig	9 deg	Down
$\psi = 90$	7	In	In	In	Rig	Rig	Rig	15 min	Down
$\psi = 270$	8	In	In	In	Rig	Rig	Rig	44 min	Down
	9	In	Out	In	Rig	Fwd	Rig	20 deg	Up
	10	In	Out	In	Rig	Aft	Rig	11 deg 40 min	Down
$\psi = 270$	11	In	In	In	Rig	Rig	Rig	44 min	Down
$\psi = 0$	12	In	In	In	Rig	Rig	Rig	39 min	Down
	13	In	In	Out	Rig	Rig	Left	10 deg 30 min	Up
	14	In	In	Out	Rig	Rig	Right	8 deg 41 min	Down
$\psi = 0$	15	In	In	In	Rig	Rig	Rig	49 min	Down
$\psi = 180$	16	In	In	In	Rig	Rig	Rig	13 min	Down
	17	In	In	Out	Rig	Rig	Left	11 deg 45 min	Down
	18	In	In	Out	Rig	Rig	Right	7 deg 33 min	Up
$\psi = 180$	19	In	In	In	Rig	Rig	Rig	9 min	Down

Table 6. Tail Rotor Angle Measurements
YAH-64 S/N 74-22249

Inboard Tail Rotor

Blade Position	Pedal Position	Blade Angle (deg)	Item
Blade 1 aft	Left forward	33 deg 20 min	1
	Right forward	13 deg 27 min	2
Blade 1 forward	Left forward	33 deg	3
	Right forward	13 deg 32 min	4
Blade 2 aft	Left forward	34 deg 26 min	5
	Right forward	12 deg 38 min	6
Blade 2 forward	Left forward	34 deg 10 min	7
	Right forward	12 deg 43 min	8

Table 7. Tail Rotor Angle Measurements
YAH-64 S/N 74-22249

Outboard Tail Rotor

Blade Position	Pedal Position	Blade Angle (deg)	Item
Blade 1 aft	Left forward	34 deg 45 min	1
	Right forward	11 deg 58 min	2
Blade 1 forward	Left forward	34 deg 57 min	3
	Right forward	12 deg	4
Blade 2 aft	Left forward	33 deg 8 min	5
	Right forward	13 deg 28 min	6
Blade 2 forward	Left forward	33 deg 30 min	7
	Right forward	13 deg 14 min	8

Table 8. Wing Flap
YAH-64 S/N 74-22249

Flap Position	Flap Angle From Trail Position
UP	37 deg 38 min
DOWN	20 deg

APPENDIX E. TEST DATA

INDEX

Table 1. Vibration Data Index

Aircraft	Configuration	Longitudinal CG	Flight Regime	Type of Plot	Figures Numbers Accelerometer Location		
					Pilot[1]	*Copilot*[1]	A/C CG[1]
74-22248	8 Hellfire	Fwd	Level Flight	Airspeed Vs Vibration Acceleration	45, 46, 47	48, 49, 50	51, 52, 53
74-22249	8 Hellfire	Fwd	Level Flight	Airspeed Vs Vibration Acceleration	54, 55, 56	57, 58, 59	60, 61, 62
74-22248	Clean	Aft	Climbs & Descents	Airspeed Vs Vibration Acceleration	63, 64, 65	66, 67, 68	69, 70, 71
74-22249	Clean	Fwd	Sideward Flight	Airspeed Vs Vibration Acceleration	72, 73, 74	75, 76, 77	78, 79, 80
74-22249	Clean	Fwd	Low Speed Fwd and Aft	Airspeed Vs Vibration Acceleration	81, 82, 83	84, 85, 86	87, 88, 89
74-22248	Clean	Aft	Right and Left Turns	Normal Accelerations Vs Vibration Acceleration	90, 91, 92	93, 94, 95	96, 97, 98
74-22248	8 Hellfire	Fwd	Level Flight	Frequency Vs Vibration Acceleration	99, 100, 101	102, 103, 104	105, 106, 107

[1] Plot sequence, vertical, lateral and longitudinal.

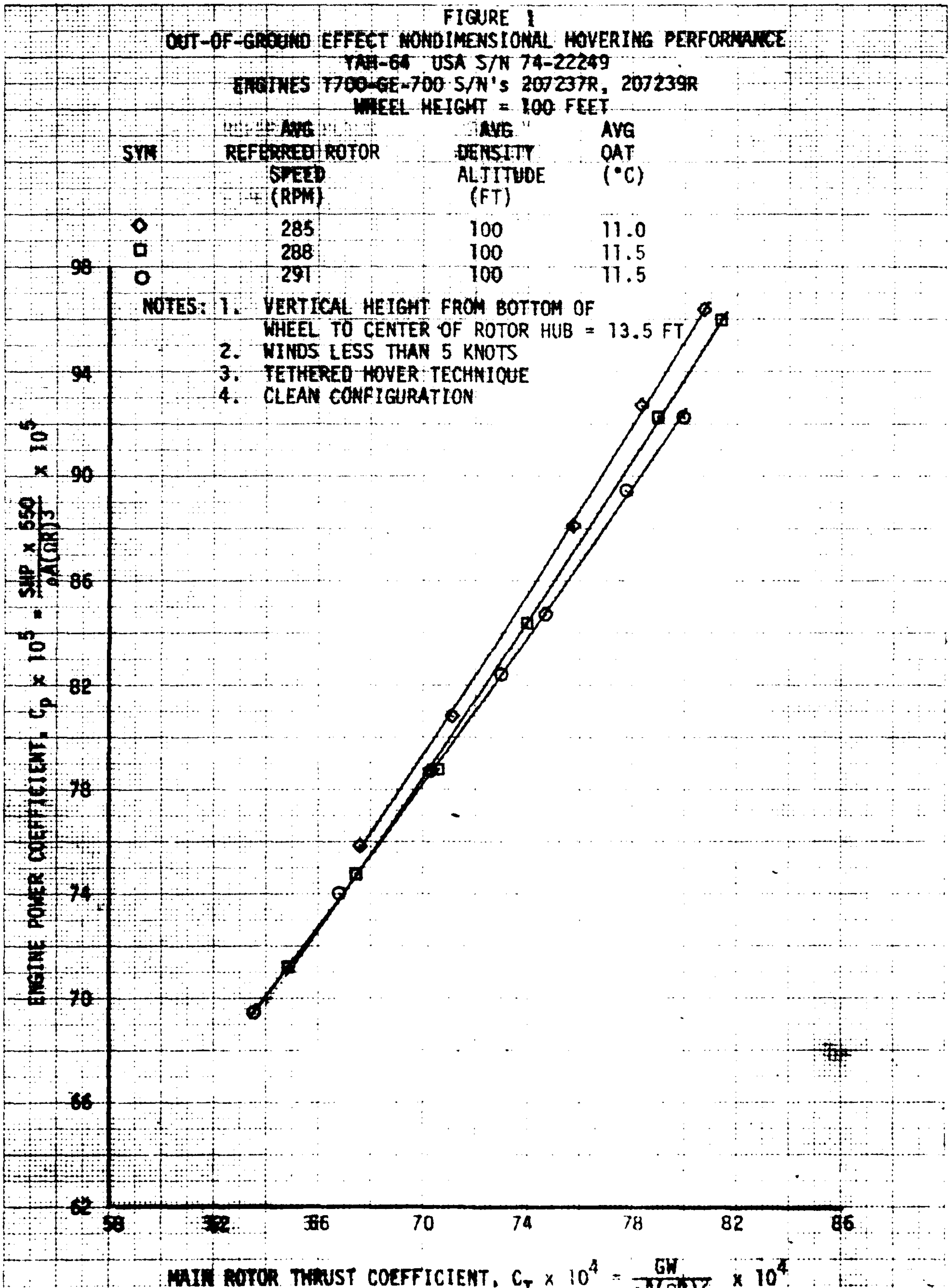
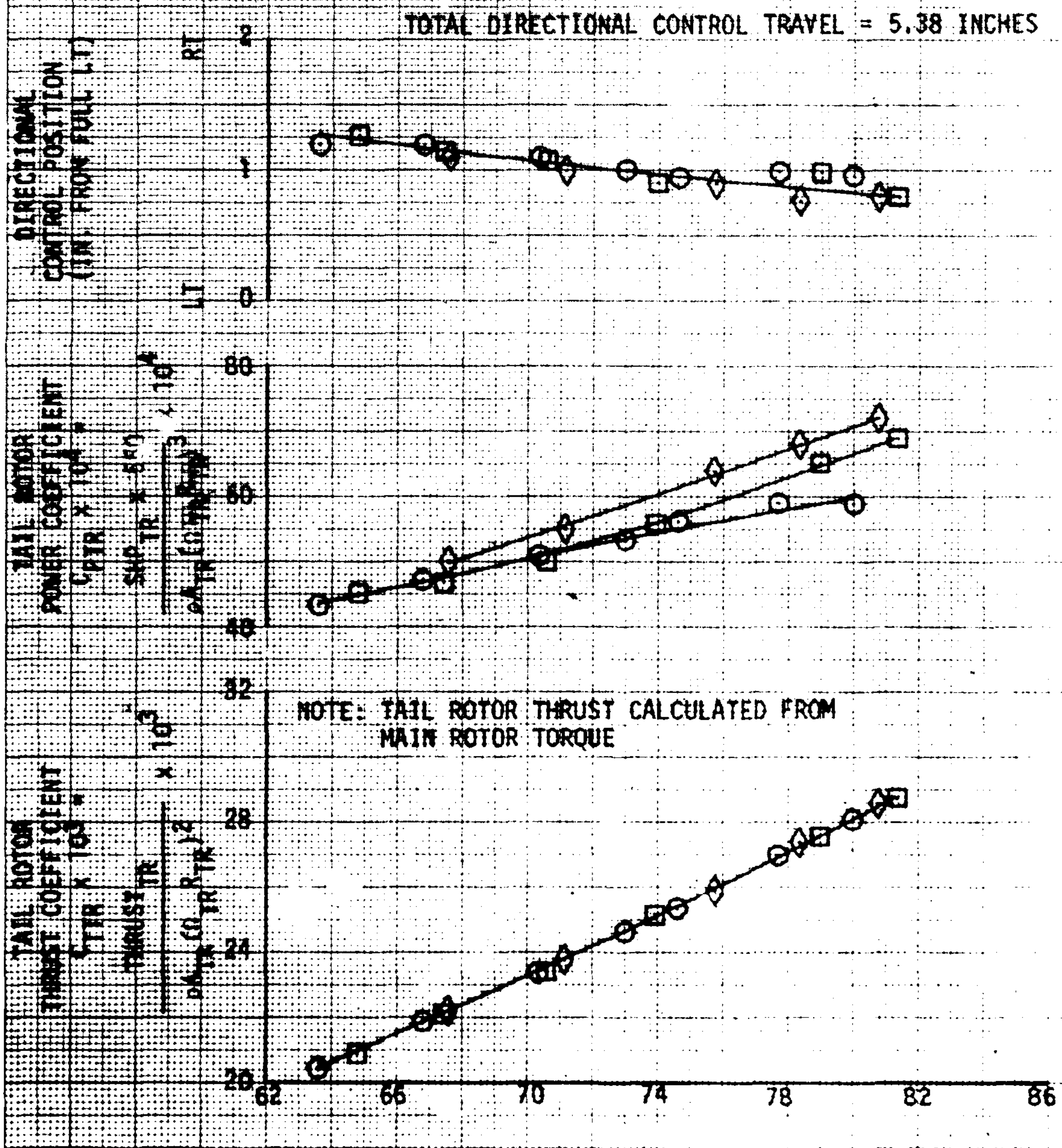


FIGURE 1
OUT-OF-GROUND EFFECT NONDIMENSIONAL HOVERING PERFORMANCE
YAH-64 USA S/N 74-22249
ENGINES T700-GE-700 S/N's 207237R, 207239R
WHEEL HEIGHT = 100 FEET
SYM
AVG REFERRED ROTOR SPEED (RPM)
AVG DENSITY ALTITUDE (FT)
AVG OAT (°C)
285
288
291
100
100
100
11.0
11.5
11.5
NOTES: 1. VERTICAL HEIGHT FROM BOTTOM OF WHEEL TO CENTER OF ROTOR HUB = 13.5 FT
2. WINDS LESS THAN 5 KNOTS
3. TETHERED HOVER TECHNIQUE
4. CLEAN CONFIGURATION
ENGINE POWER COEFFICIENT, $C_P \times 10^5 = \frac{SHP \times 550}{\rho A(\Omega R)^3} \times 10^5$
MAIN ROTOR THRUST COEFFICIENT, $C_T \times 10^4 = \frac{GW}{\rho A(\Omega R)^2} \times 10^4$
98
94
90
86
82
78
74
70
66
62
58
62
66
70
74
78
82
86

FIGURE 2
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
YAH-64 USA SN 74-22249
ENGINES YT700-GE-700 SN 207245R, 207248R

SYMBOL	AVG [redacted] ROTOR SPEED (RPM)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	WHEEL HEIGHT (FT)
○	291	100	11.5	100
□	288	100	11.5	100
◇	286	100	11.0	100



$C_{PTR} \times 10^4 = \frac{SHP_{TR} \times 550}{\rho A_{TR}(\Omega_{TR} R_{TR})^3} \times 10^4$

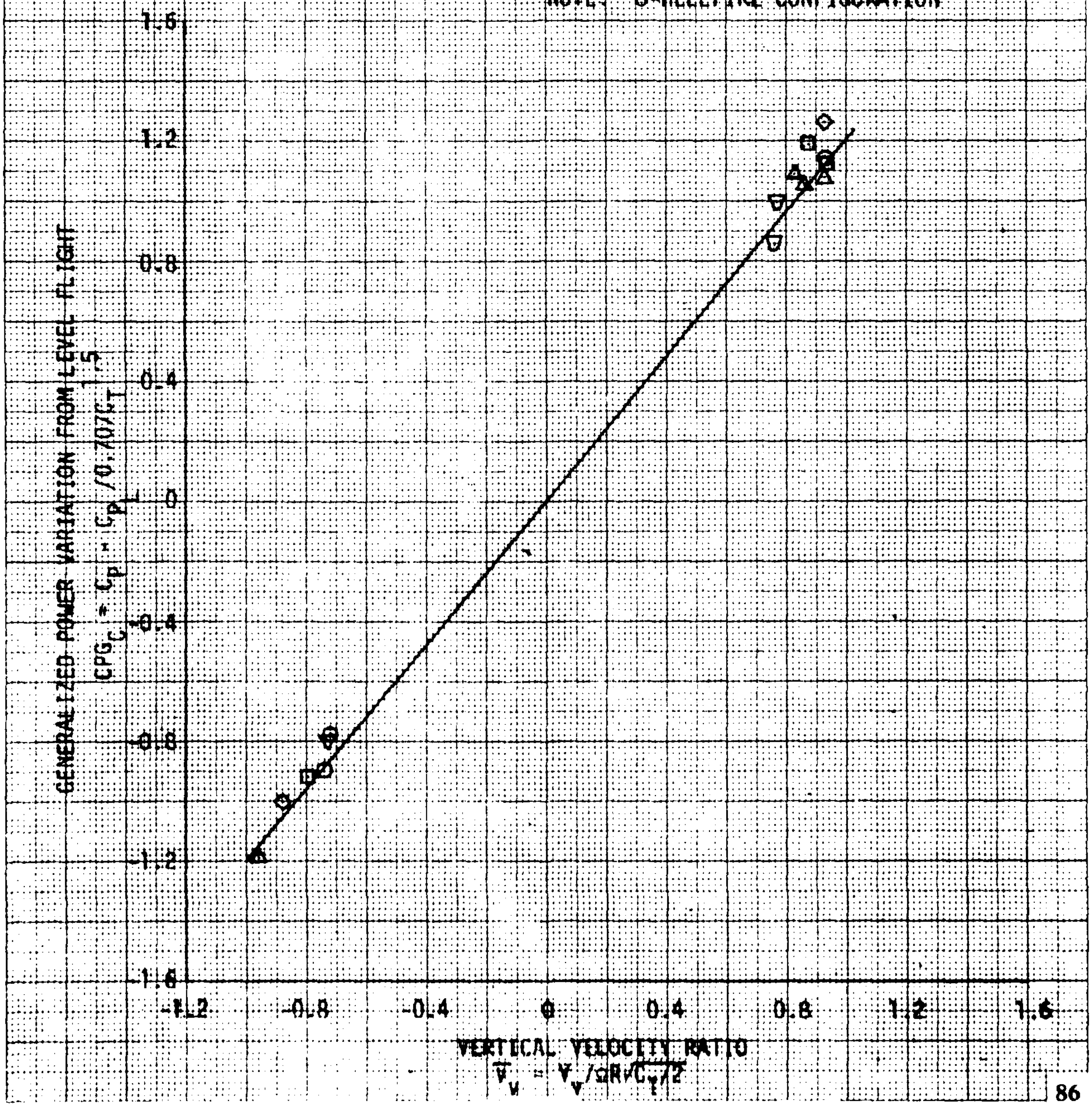
$C_{TTR} \times 10^3 = \frac{THRUST_{TR}}{\rho A_{TR}(\Omega_{TR} R_{TR})^2} \times 10^3$

MAIN ROTOR THRUST COEFFICIENT ~ $C_T \times 10^4 = \frac{GW}{\rho A(\Omega R)^2} \times 10^4$

FIGURE 3
GENERALIZED CLIMB AND DESCENT PERFORMANCE
YAH-64 USA S/N 74-22248

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	FORWARD VELOCITY RATIO
○	14260	206.9(AFT)	-0.5 LT	16.0	290	0.007631	2.9
▽	14220	206.9(AFT)	-0.5 LT	16.5	289	0.007141	3.3
□	14160	206.9(AFT)	-0.5 LT	16.0	290	0.007321	3.7
◇	14100	207.0(AFT)	-0.5 LT	16.0	290	0.007055	4.1
△	14020	207.0(AFT)	-0.5 LT	16.0	291	0.007218	4.5
▽	13940	207.0(AFT)	-0.5 LT	15.5	290	0.007248	4.9

NOTE: 8-HELLFIRE CONFIGURATION



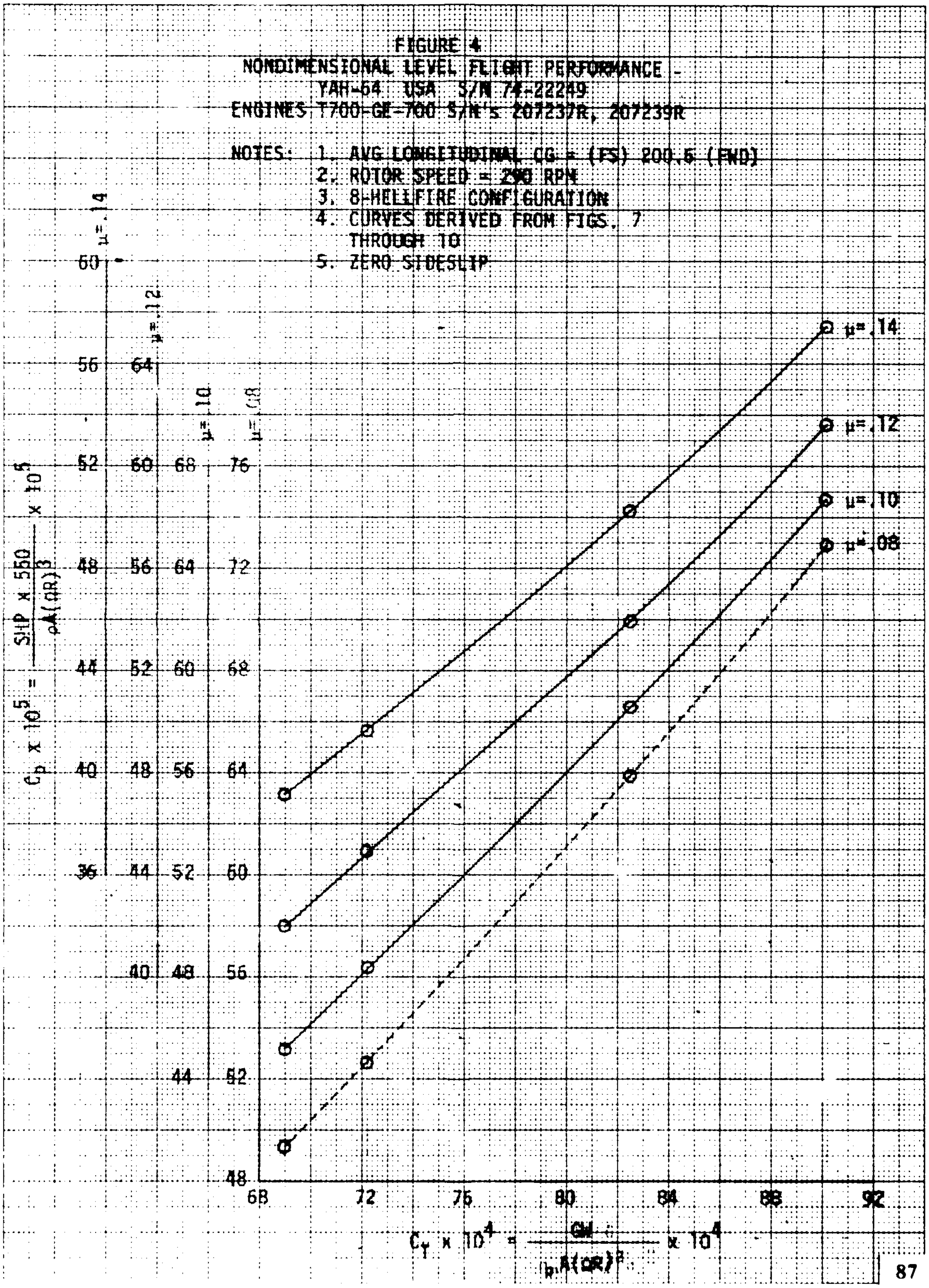


FIGURE 4
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 74-22249
ENGINES T700-GE-700 S/N's 207237R, 207239R
NOTES: 1. AVG LONGITUDINAL CG = (FS) 200.6 (FWD)
2. ROTOR SPEED = 290 RPM
3. 8-HELLFIRE CONFIGURATION
4. CURVES DERIVED FROM FIGS. 7 THROUGH 10
5. ZERO SIDESLIP
μ=.14
μ=.12
μ=.10
μ=.08
$C_P \times 10^5 = \frac{SHP \times 550}{\rho A(\Omega R)^3} \times 10^5$
$C_T \times 10^4 = \frac{GW}{\rho A(\Omega R)^2} \times 10^4$
68
72
76
80
84
88
92

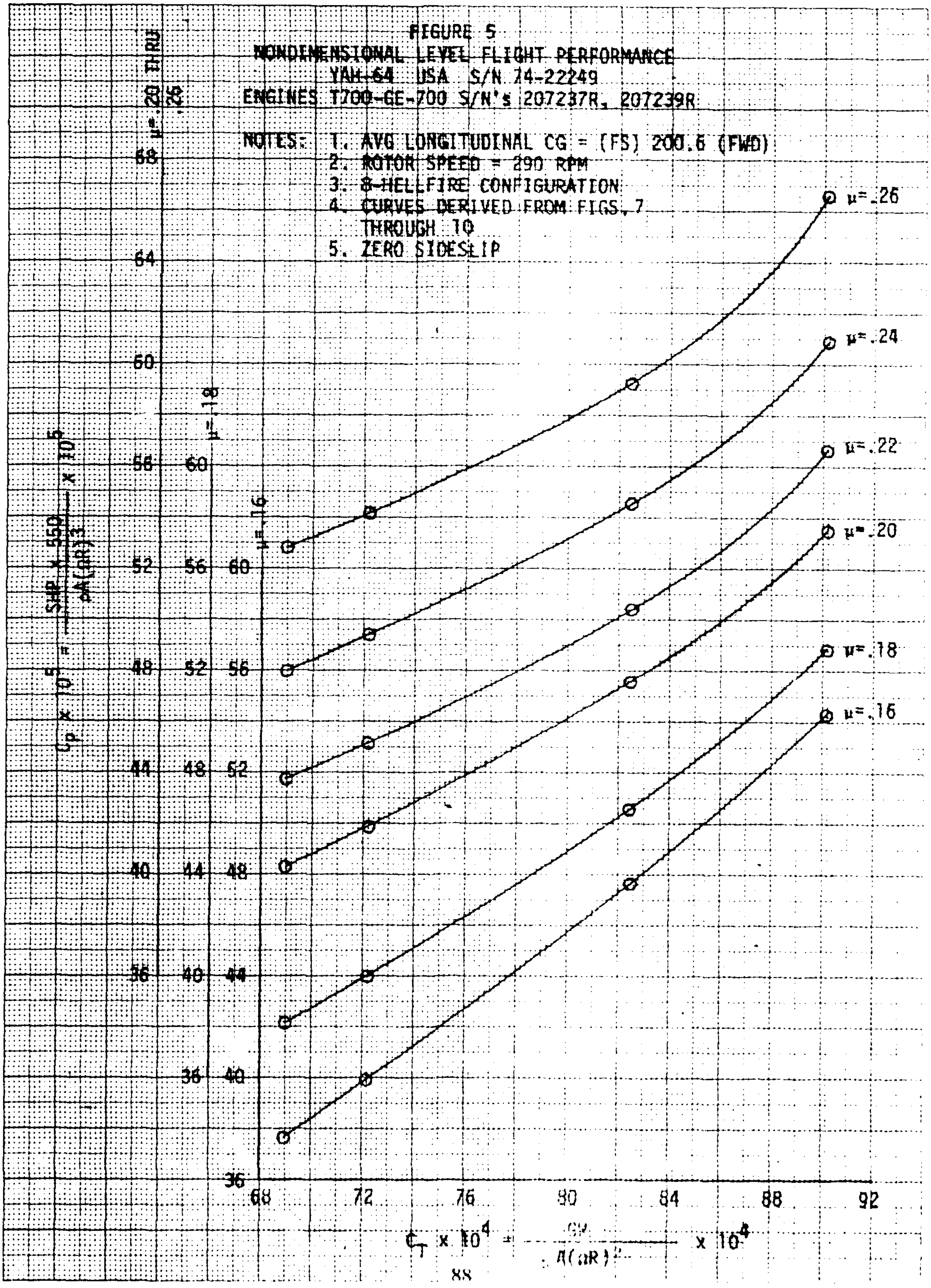


FIGURE 5
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 74-22249
ENGINES T700-GE-700 S/N's 207237R, 207239R
NOTES: 1. AVG LONGITUDINAL CG = (FS) 200.6 (FWD)
2. ROTOR SPEED = 290 RPM
3. 8-HELLFIRE CONFIGURATION
4. CURVES DERIVED FROM FIGS. 7 THROUGH 10
5. ZERO SIDESLIP
μ=.26
μ=.24
μ=.22
μ=.20
μ=.18
μ=.16
μ=.20 THRU .26
μ=.18
μ=.16
$C_P \times 10^5 = \frac{SHP \times 550}{\rho A(\Omega R)^3} \times 10^5$
$C_T \times 10^4 = \frac{GW}{\rho A(\Omega R)^2} \times 10^4$

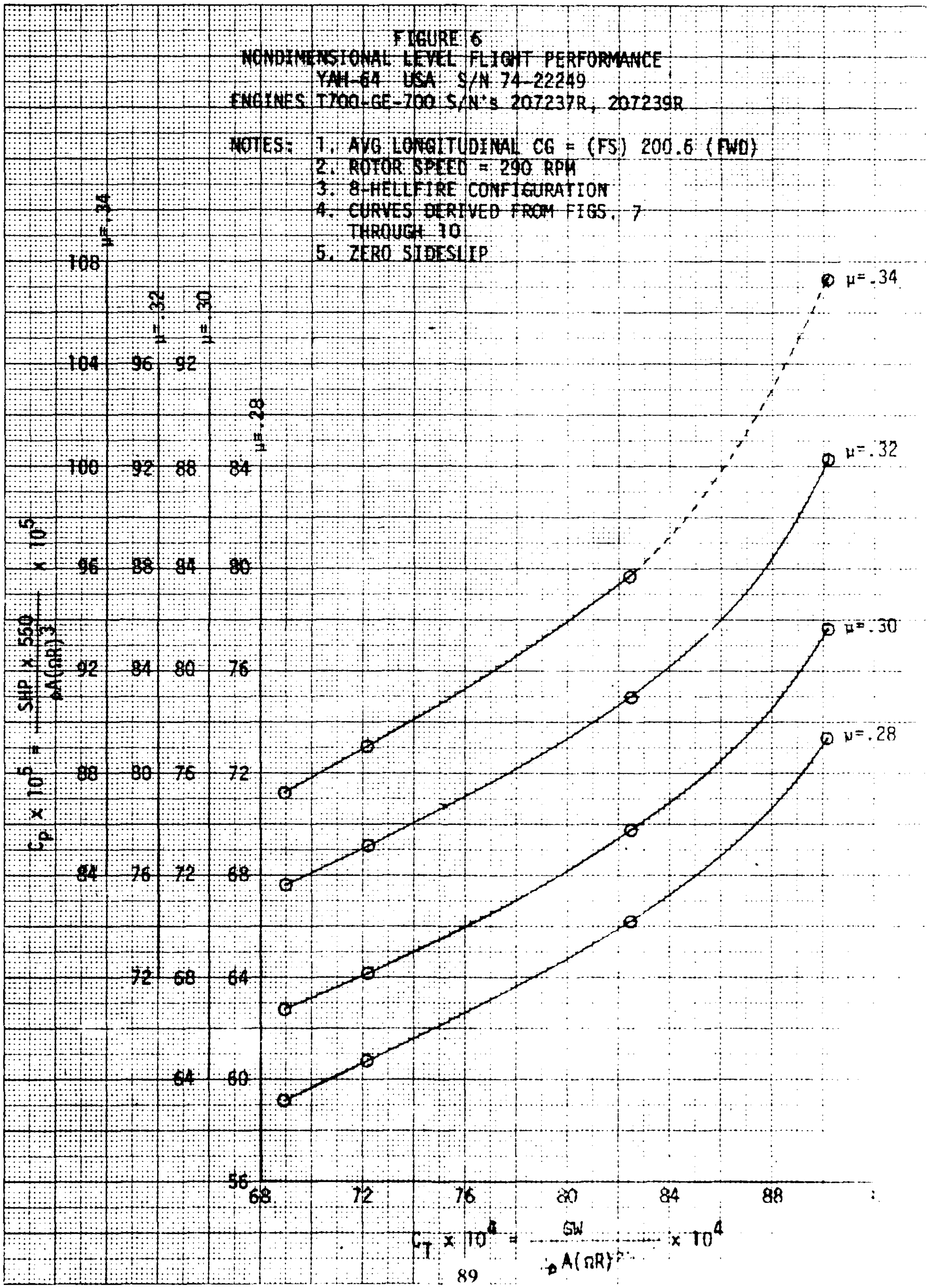


FIGURE 6
NONDIMENSIONAL LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 74-22249
ENGINES T700-GE-700 S/N's 207237R, 207239R
NOTES: 1. AVG LONGITUDINAL CG = (FS) 200.6 (FWD)
2. ROTOR SPEED = 290 RPM
3. 8-HELLFIRE CONFIGURATION
4. CURVES DERIVED FROM FIGS. 7 THROUGH 10
5. ZERO SIDESLIP
μ=.34
μ=.32
μ=.30
μ=.28
$C_P \times 10^5 = \frac{SHP \times 550}{\rho A(\Omega R)^3} \times 10^5$
$C_T \times 10^4 = \frac{GW}{\rho A(\Omega R)^2} \times 10^4$

FIGURE 7
LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 74-22249
ENGINES T700-GE-700 S/N's 207237R, 207239R

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
14720	200.5(FWD)	0.6 LT	2300	17.0	290	0.006894	8-HELLFIRE

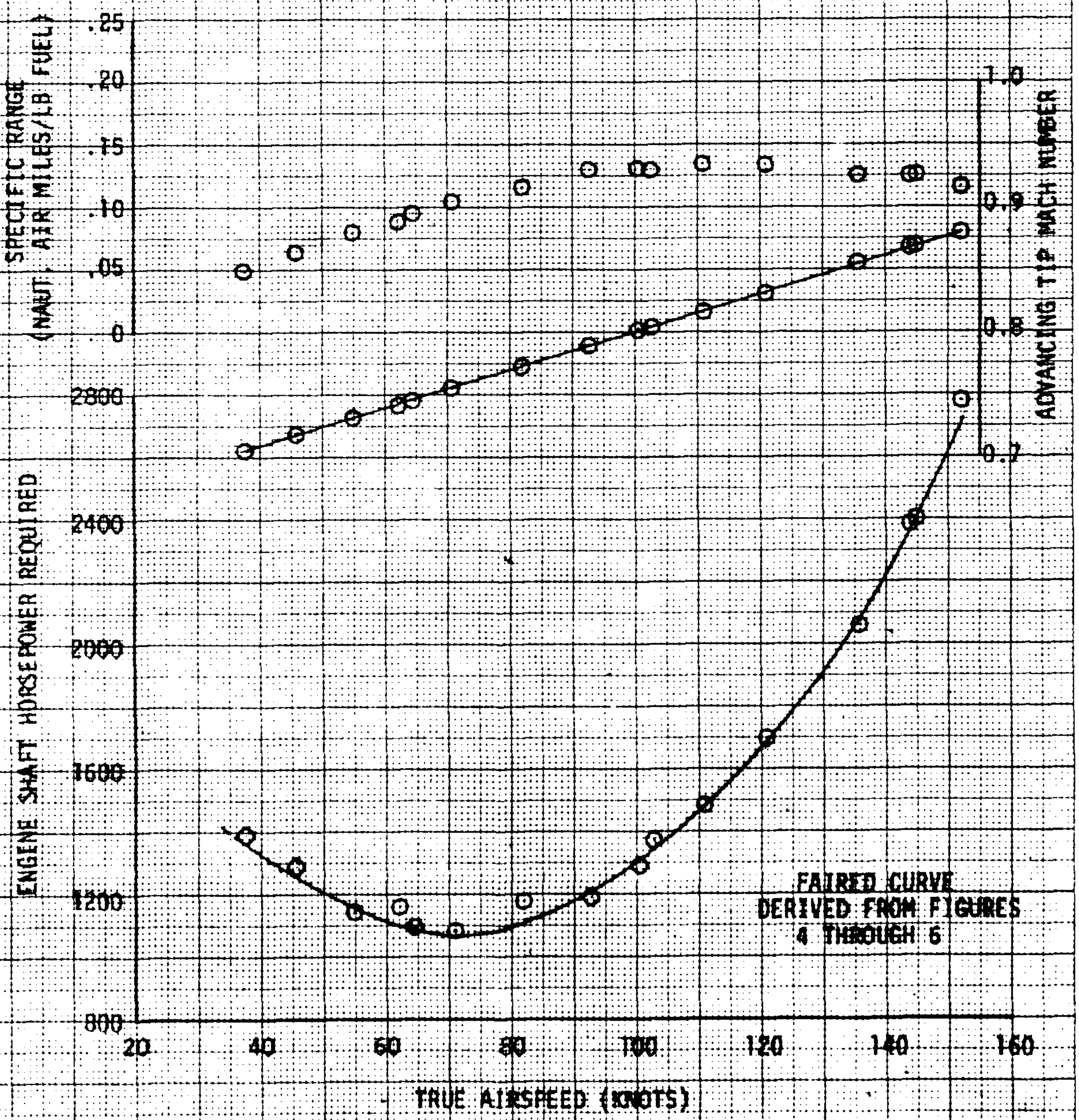


FIGURE 8
LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 74-22249
ENGINES T700-GE-700 S/N's 207237R, 207239R

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
14700	200.6(FWD)	-0.6 LT	3920	4.0	290	0.007226	8-HELLFIRE

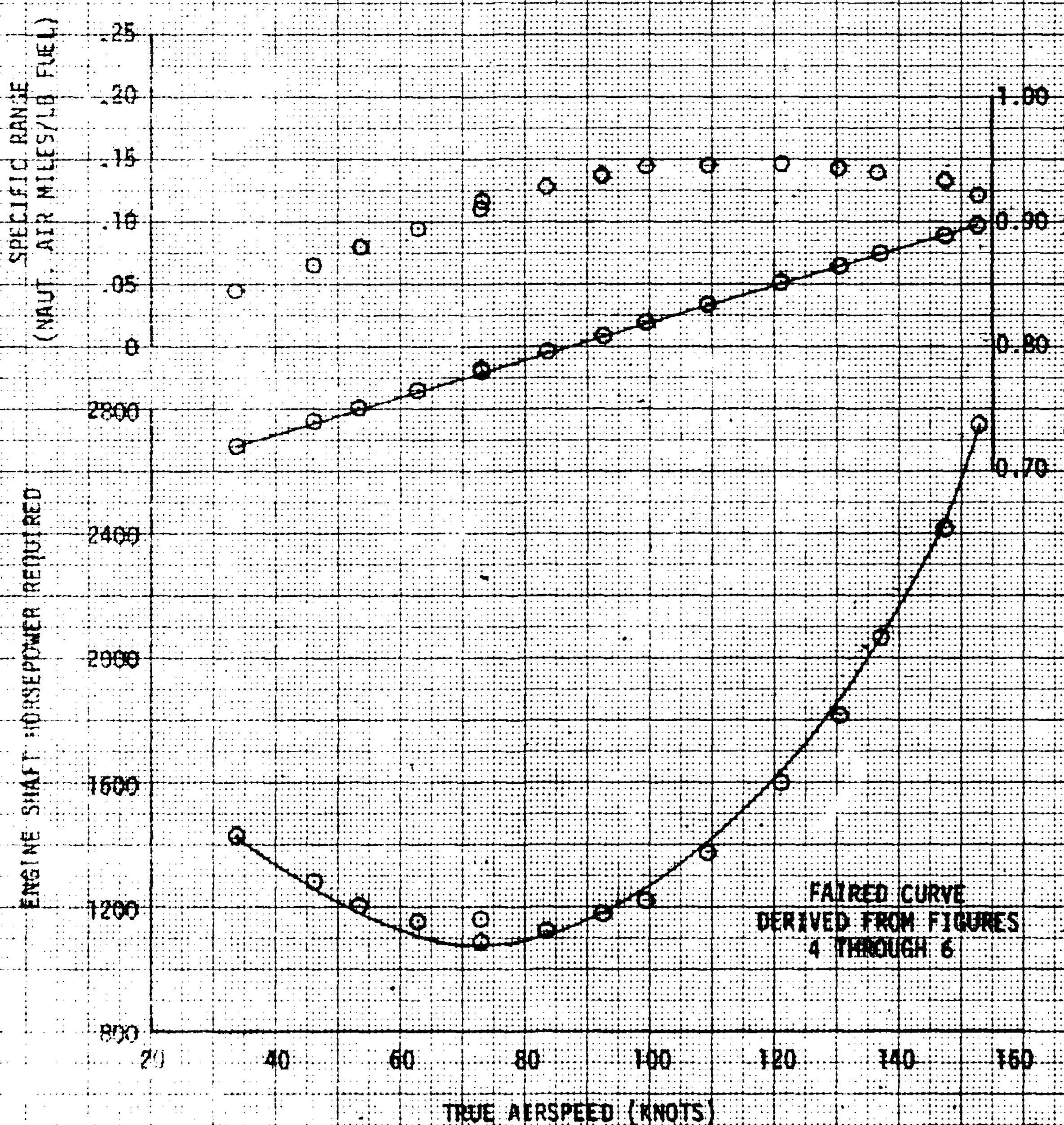


FIGURE 9
LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 74-22249
ENGINES T700-GE-700 S/N's 207237R, 207239R

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
14680	200.3(FWD)	-0.6 LT	8280	12.5	290	0.008249	8-HELLFIRE

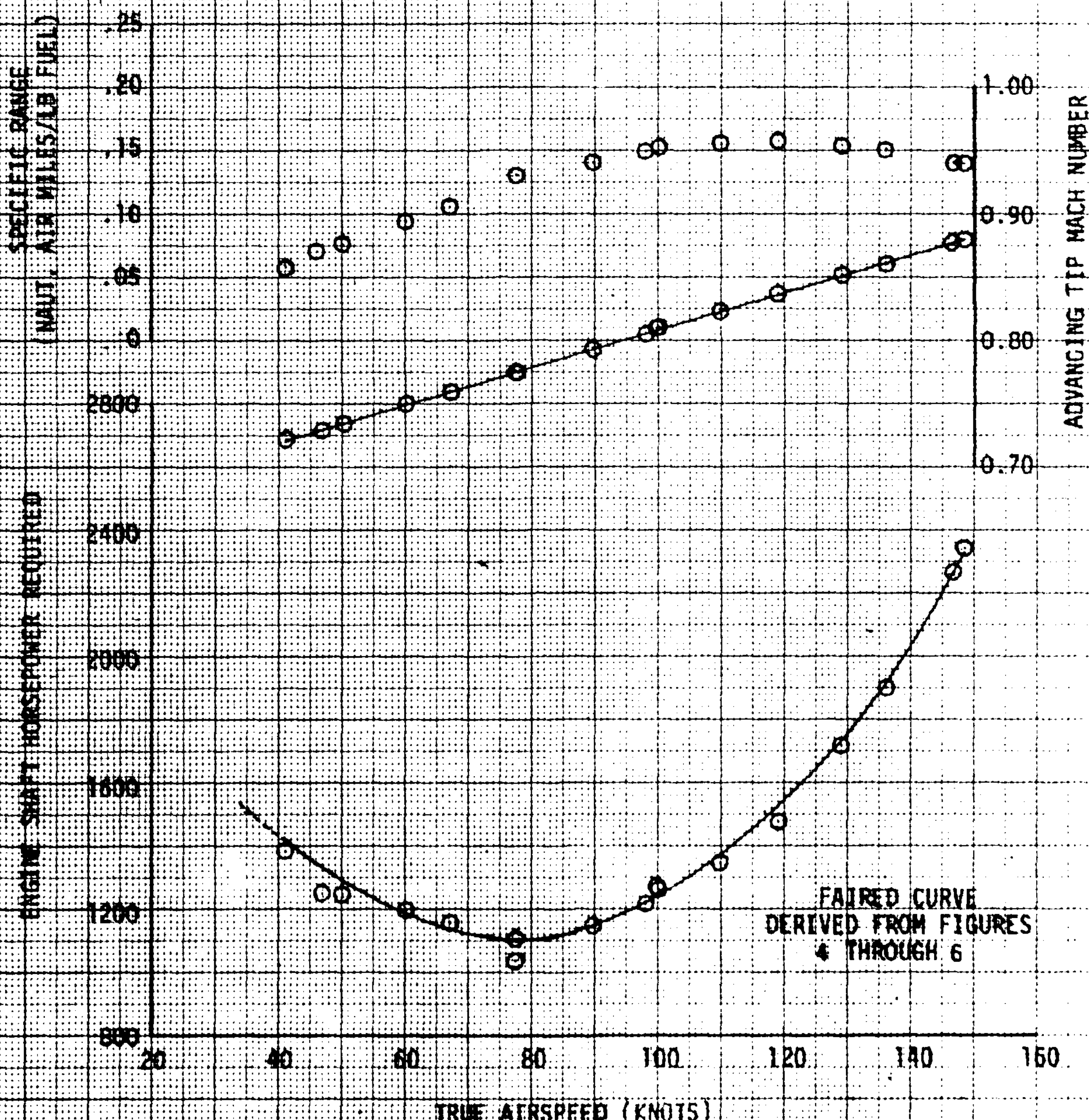


FIGURE 10
LEVEL FLIGHT PERFORMANCE
YAH-64 USA S/N 74-22249
ENGINES T700-GE-700 S/N's 207237R, 207239R

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG C_T	CONFIGURATION
14760	200.9(FWD)	0.6 LT	10960	7.5	290	0.009018	8-HELLFIRE

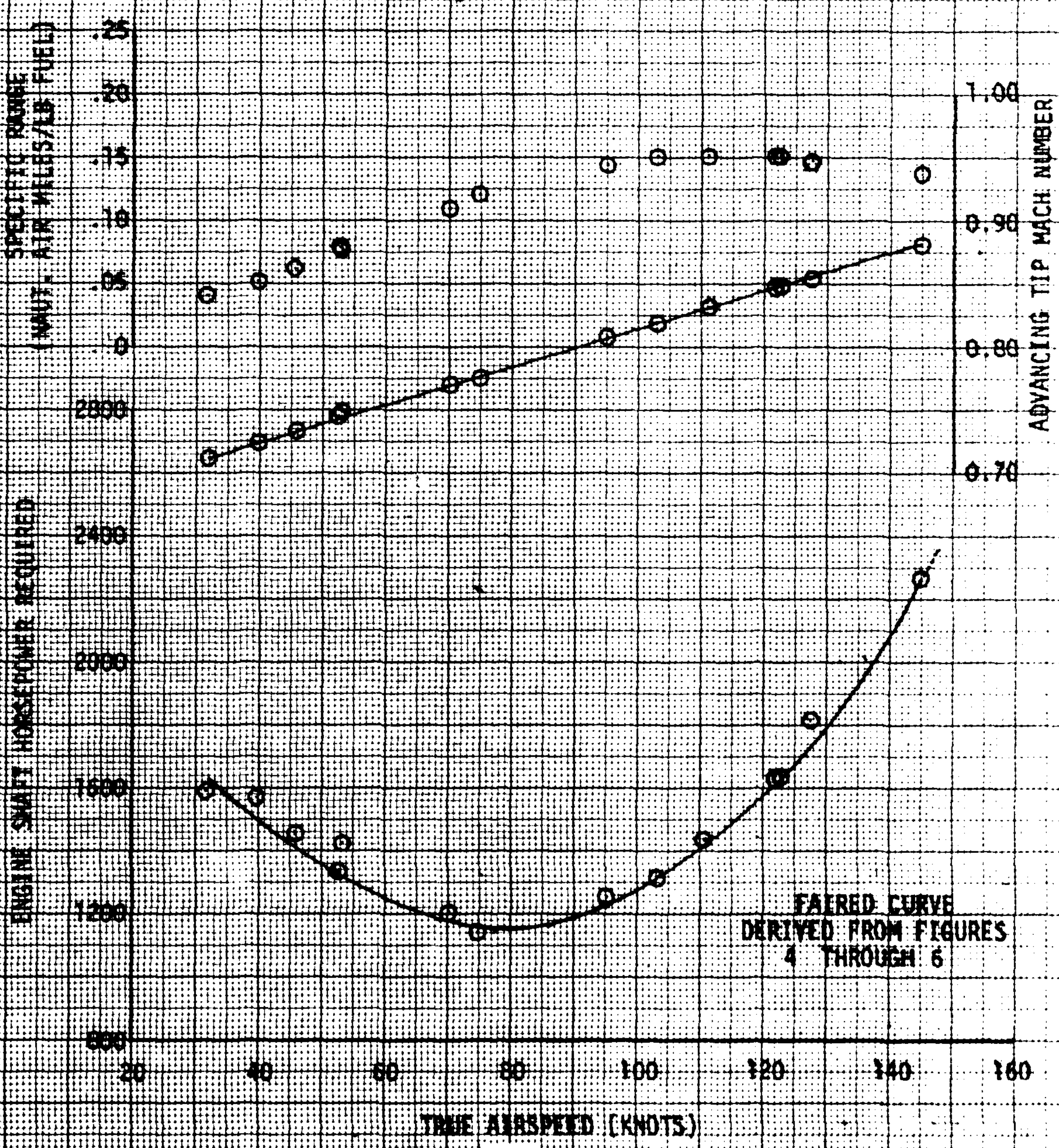
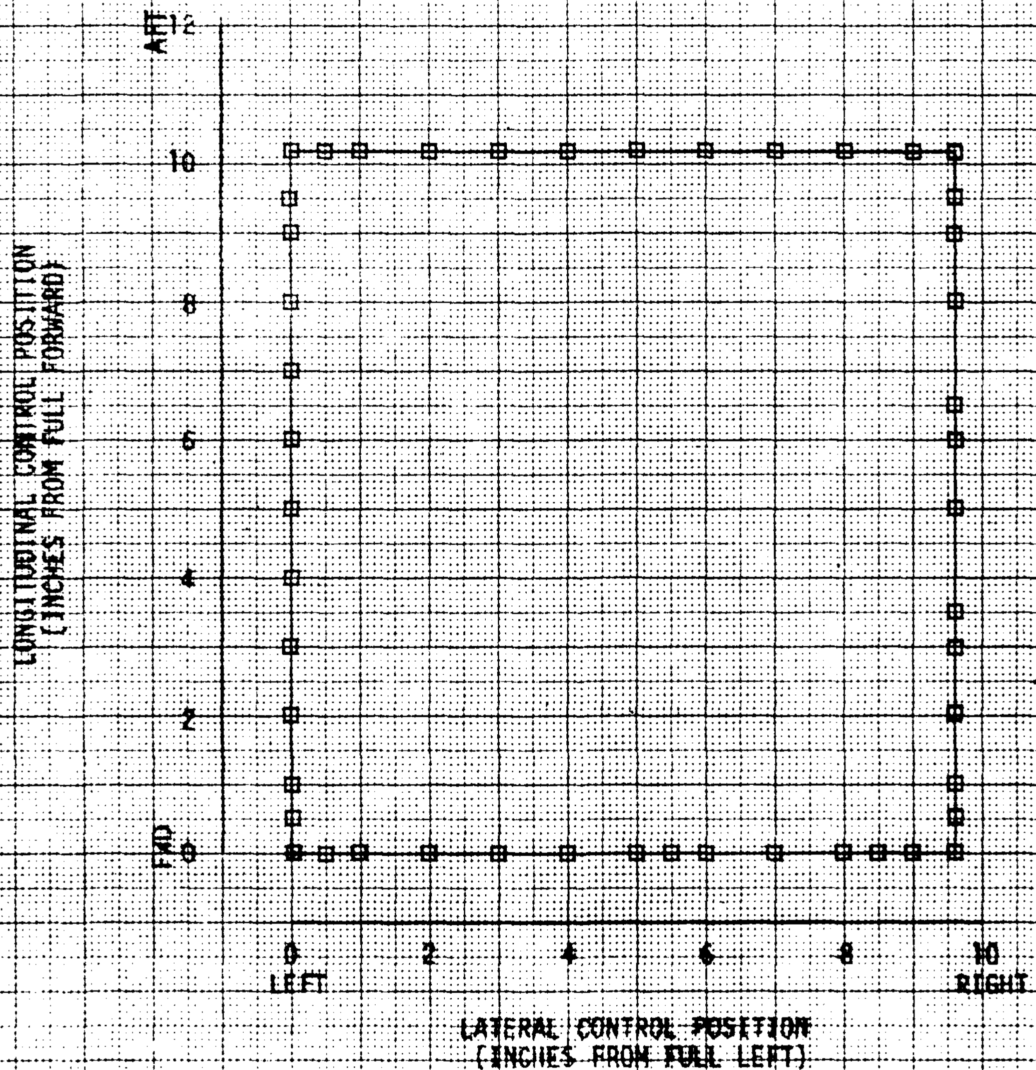


FIGURE 11
LIMITS OF CYCLIC CONTROL TRAVEL
YAH-64 USA S/N 74-22248

NOTES:
1. ROTORS STATIC
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
3. CONTROL POSITION MEASURED AT CENTER OF GRIP
4. COLLECTIVE CONTROL FULL DOWN
5. NO CYCLIC CONTROL PATTERN CHANGE WITH CHANGE OF COLLECTIVE CONTROL POSITION



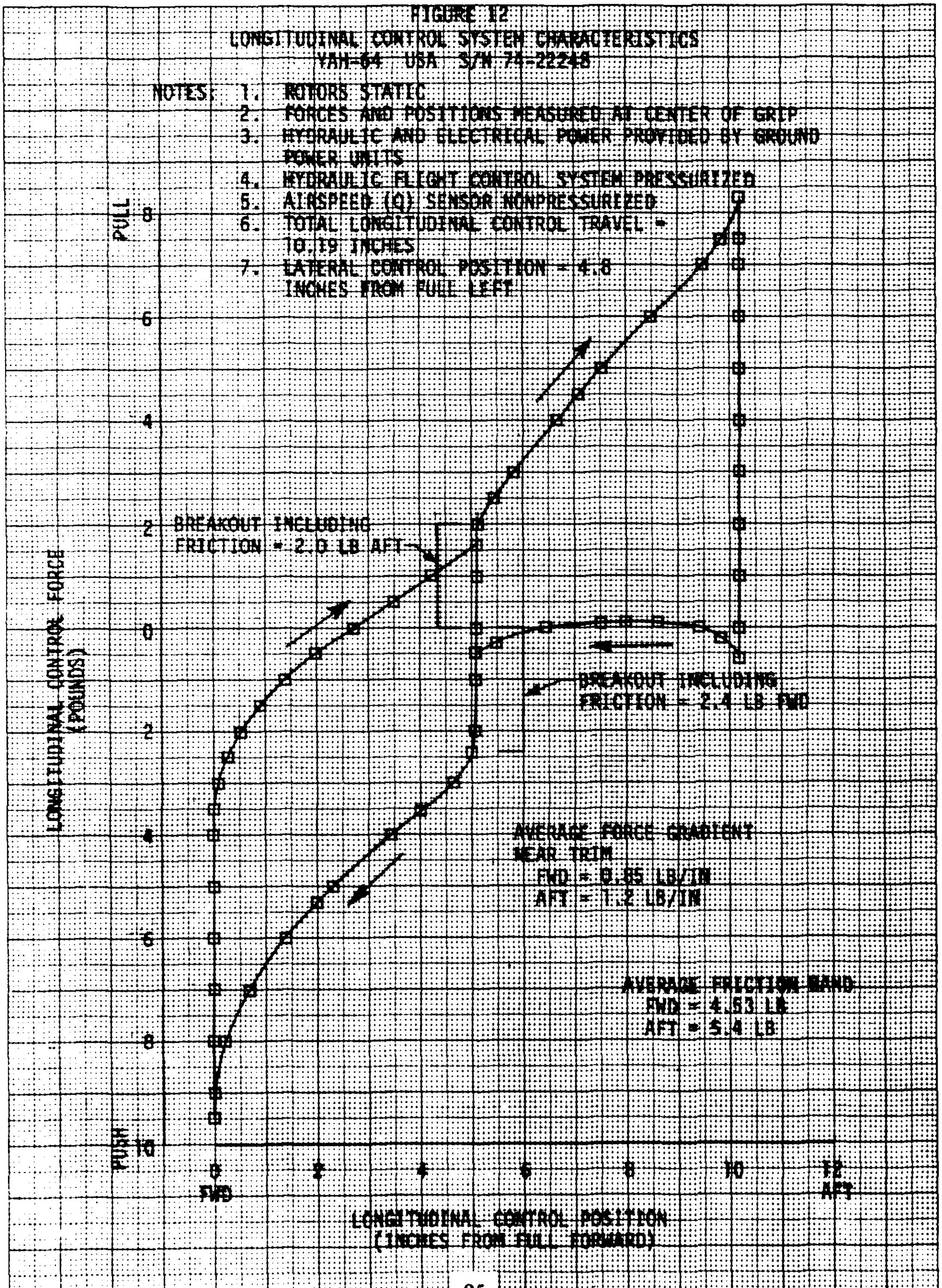


FIGURE 12
LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 74-22248
NOTES: 1. ROTORS STATIC
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4. HYDRAULIC FLIGHT CONTROL SYSTEM PRESSURIZED
5. AIRSPEED (Q) SENSOR NONPRESSURIZED
6. TOTAL LONGITUDINAL CONTROL TRAVEL = 10.19 INCHES
7. LATERAL CONTROL POSITION = 4.8 INCHES FROM FULL LEFT
BREAKOUT INCLUDING FRICTION = 2.0 LB AFT
BREAKOUT INCLUDING FRICTION = 2.4 LB FWD
AVERAGE FORCE GRADIENT NEAR TRIM
FWD = 0.85 LB/IN
AFT = 1.2 LB/IN
AVERAGE FRICTION BAND
FWD = 4.53 LB
AFT = 5.4 LB
PULL
PUSH
LONGITUDINAL CONTROL FORCE (POUNDS)
8
6
4
2
0
2
4
6
8
10
0
2
4
6
8
10
12
FWD
AFT
LONGITUDINAL CONTROL POSITION (INCHES FROM FULL FORWARD)

FIGURE 13
LATERAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 74-22248

NOTES:
1. ROTORS STATIC
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4. HYDRAULIC FLIGHT CONTROL SYSTEM PRESSURIZED
5. AIRSPEED (Q) SENSOR NONPRESSURIZED
6. TOTAL LATERAL CONTROL TRAVEL = 9.60 INCHES
7. LONGITUDINAL CONTROL POSITION = 5.1 INCHES FROM FULL FORWARD

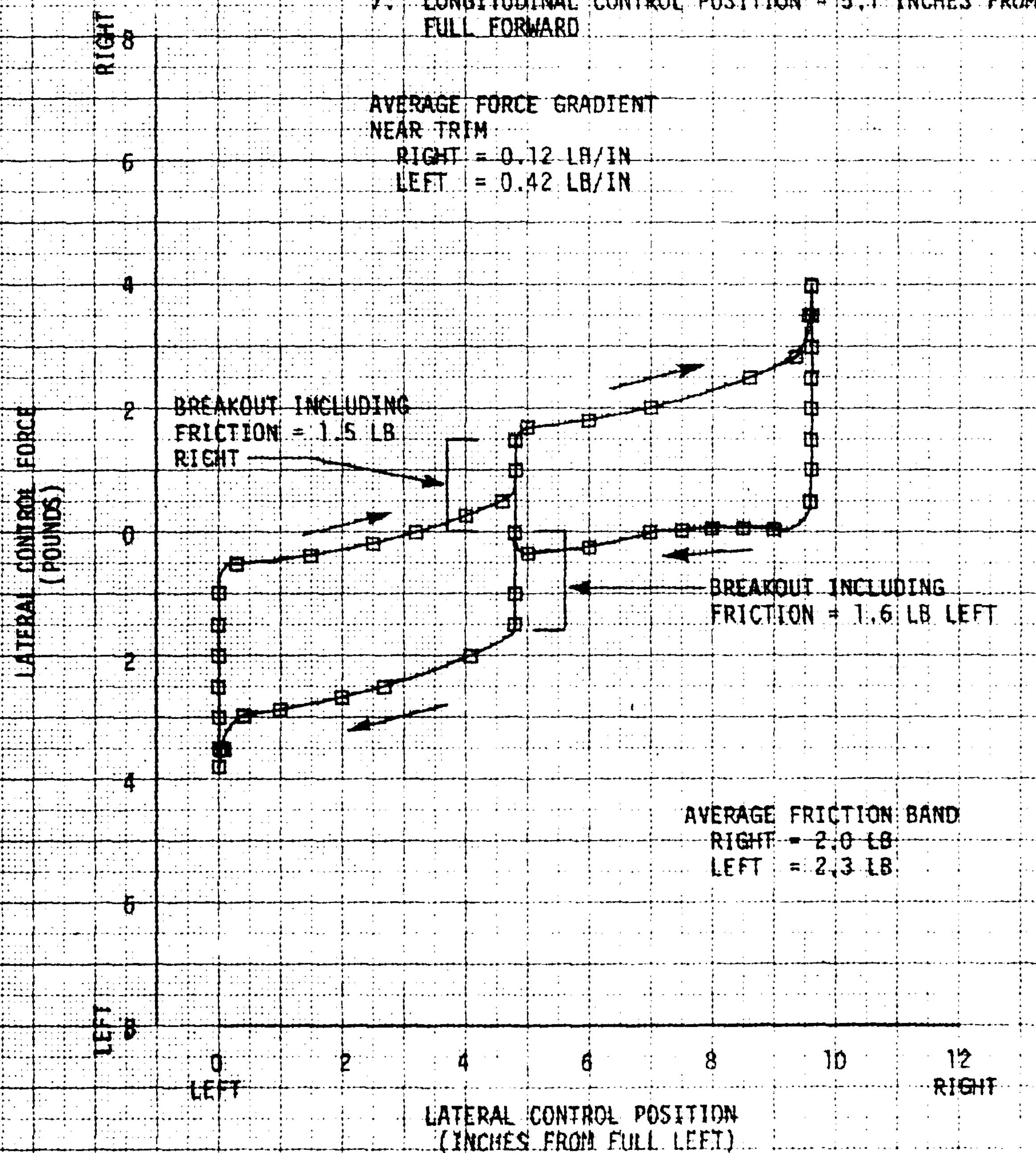


FIGURE 14
DIRECTIONAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 74-22248

NOTES:
1. ROTORS STATIC
2. FORCES MEASURED AT THE DIRECTIONAL CONTROL
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4. HYDRAULIC FLIGHT CONTROL SYSTEM PRESSURIZED
5. AIRSPEED (Q) SENSOR NONPRESSURIZED
6. TOTAL DIRECTIONAL CONTROL TRAVEL = 5.43 INCHES

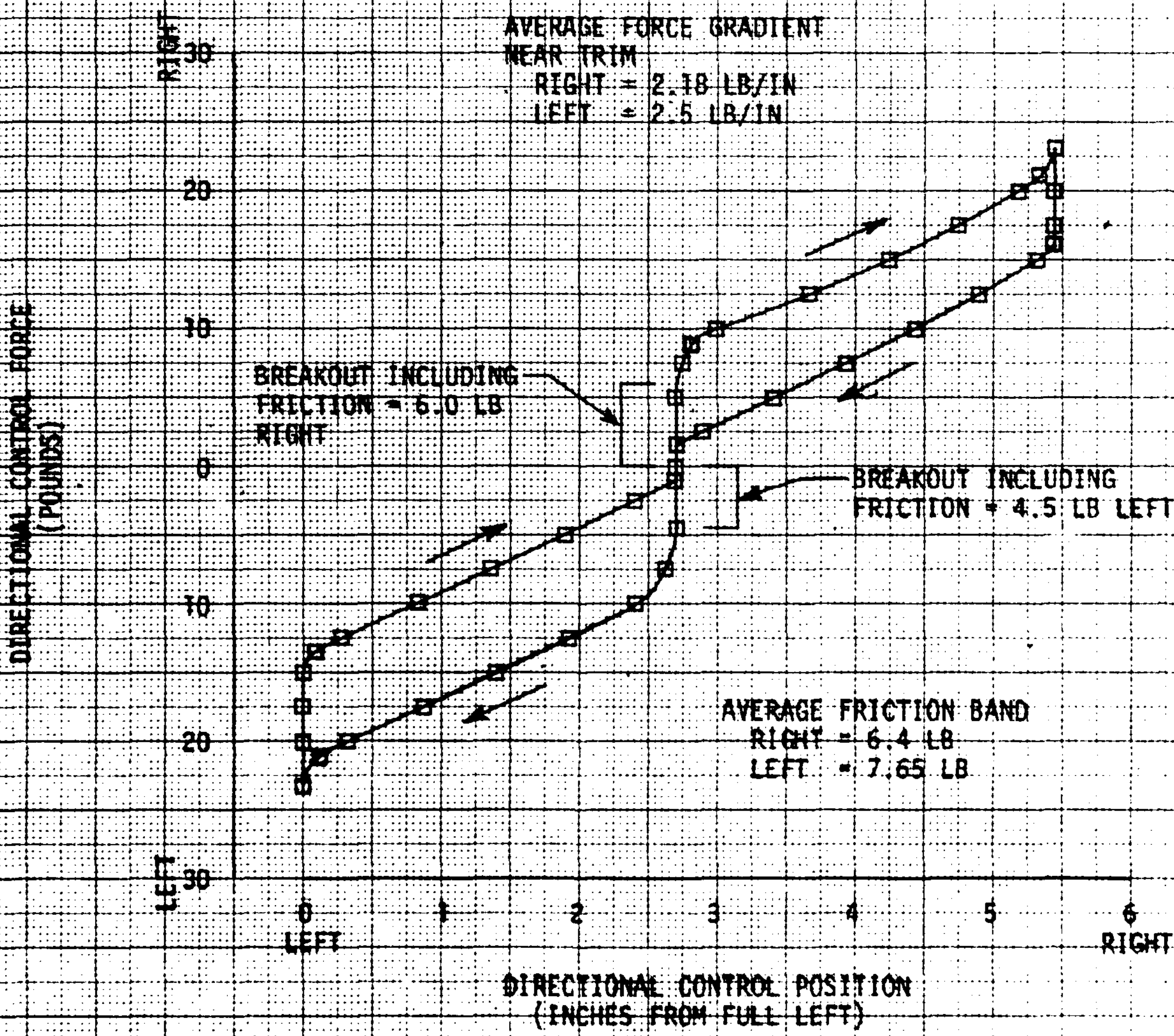
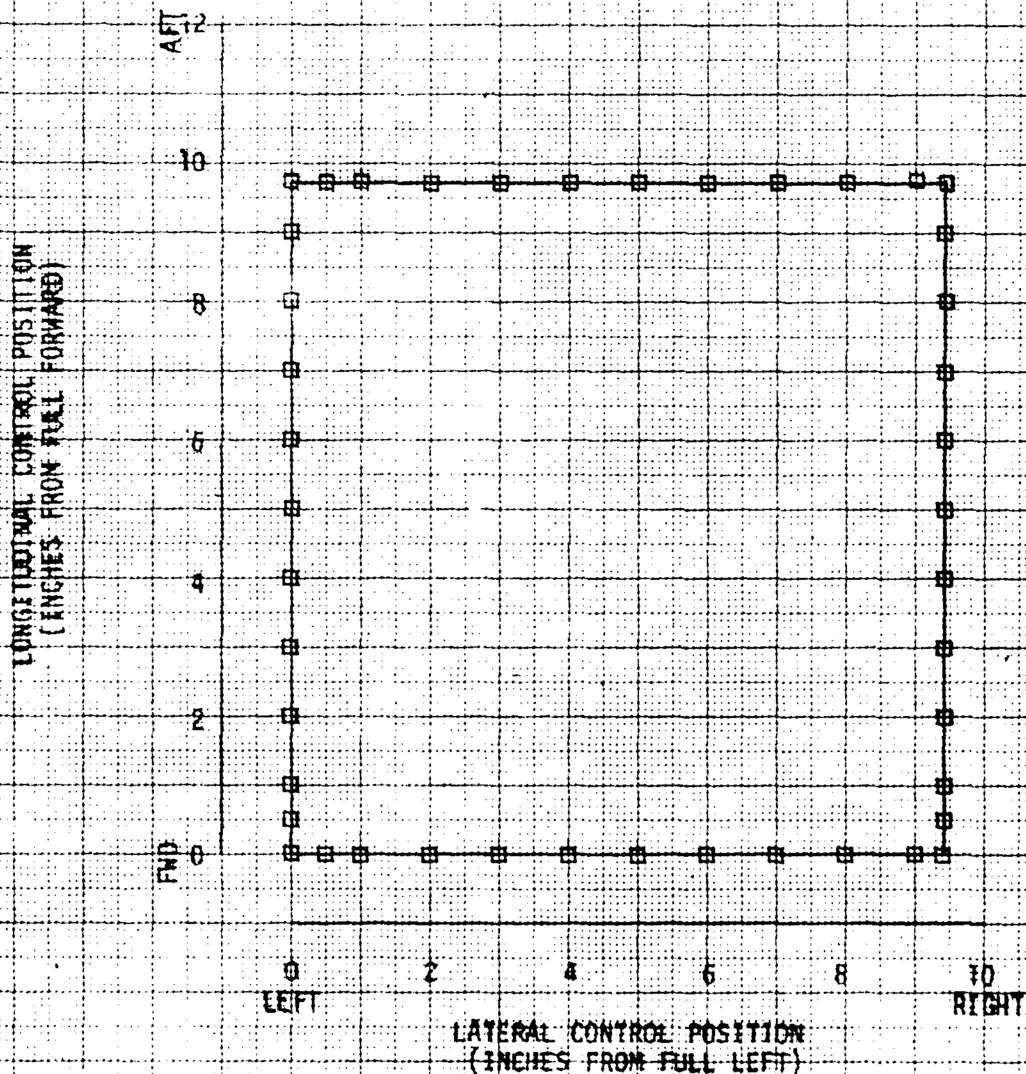


FIGURE 15

LIMITS OF CYCLIC CONTROL TRAVEL
YAH-64 USA S/N 74-22249

NOTES:
1. ROTORS STATIC
2. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
3. CONTROL POSITION MEASURED AT CENTER OF GRIP
4. COLLECTIVE CONTROL FULL DOWN
5. NO CYCLIC CONTROL PATTERN CHANGE WITH CHANGE OF COLLECTIVE CONTROL POSITION



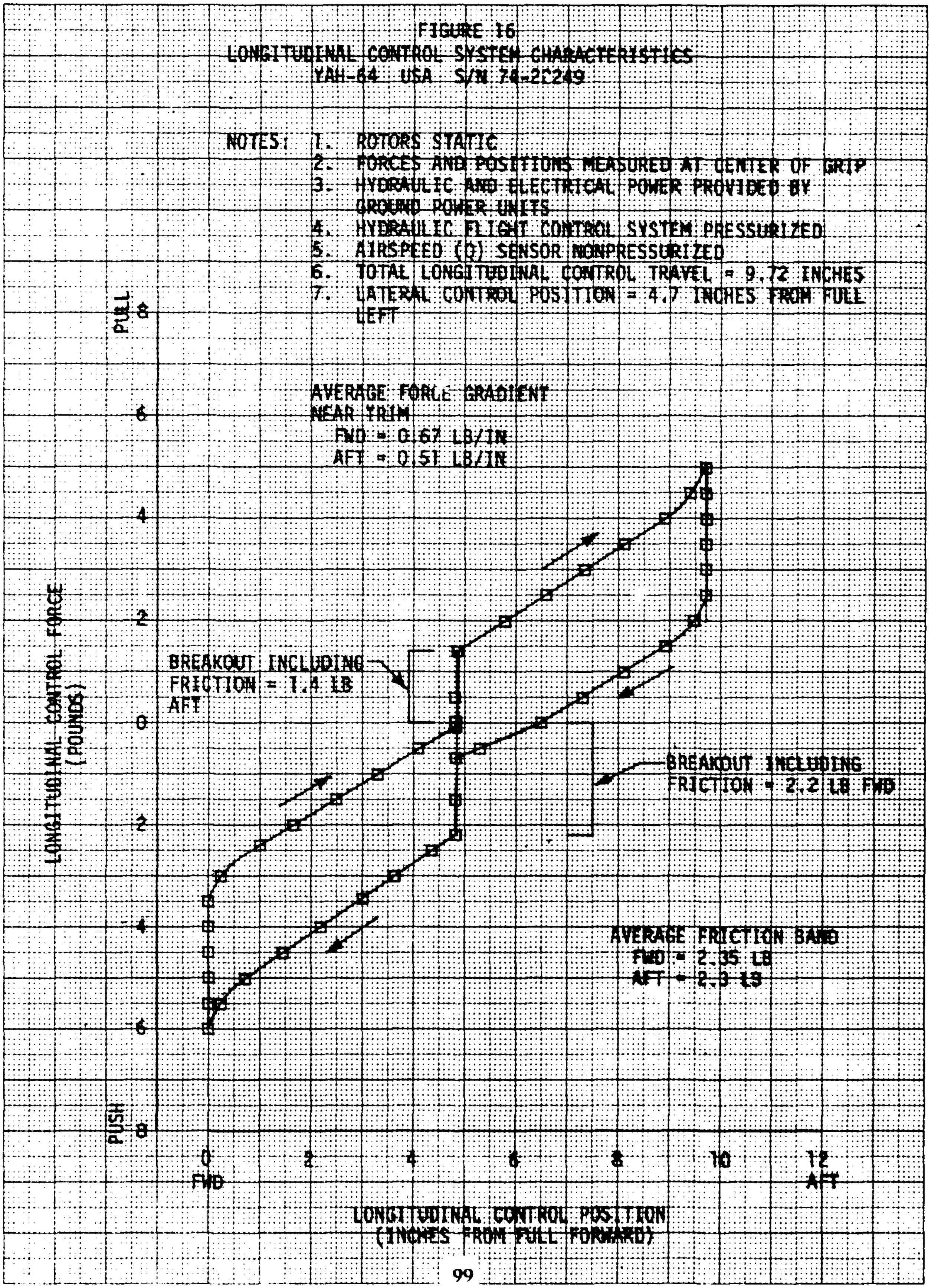


FIGURE 16
LONGITUDINAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 74-22249
NOTES: 1. ROTORS STATIC
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4. HYDRAULIC FLIGHT CONTROL SYSTEM PRESSURIZED
5. AIRSPEED (Q) SENSOR NONPRESSURIZED
6. TOTAL LONGITUDINAL CONTROL TRAVEL = 9.72 INCHES
7. LATERAL CONTROL POSITION = 4.7 INCHES FROM FULL LEFT
AVERAGE FORCE GRADIENT NEAR TRIM
FWD = 0.67 LB/IN
AFT = 0.51 LB/IN
BREAKOUT INCLUDING FRICTION = 1.4 LB AFT
BREAKOUT INCLUDING FRICTION = 2.2 LB FWD
AVERAGE FRICTION BAND
FWD = 2.35 LB
AFT = 2.3 LB
PULL
PUSH
LONGITUDINAL CONTROL FORCE (POUNDS)
8
6
4
2
0
-2
-4
-6
-8
0
2
4
6
8
10
12
FWD
AFT
LONGITUDINAL CONTROL POSITION (INCHES FROM FULL FORWARD)

FIGURE 17
LATERAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 74-22249

NOTES:
1. ROTORS STATIC
2. FORCES AND POSITIONS MEASURED AT CENTER OF GRIP
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4. HYDRAULIC FLIGHT CONTROL SYSTEM PRESSURIZED
5. AIRSPEED (Q) SENSOR NONPRESSURIZED
6. TOTAL LATERAL CONTROL TRAVEL = 9.42 INCHES
7. LONGITUDINAL CONTROL POSITION = 4.85 INCHES FROM FULL FORWARD

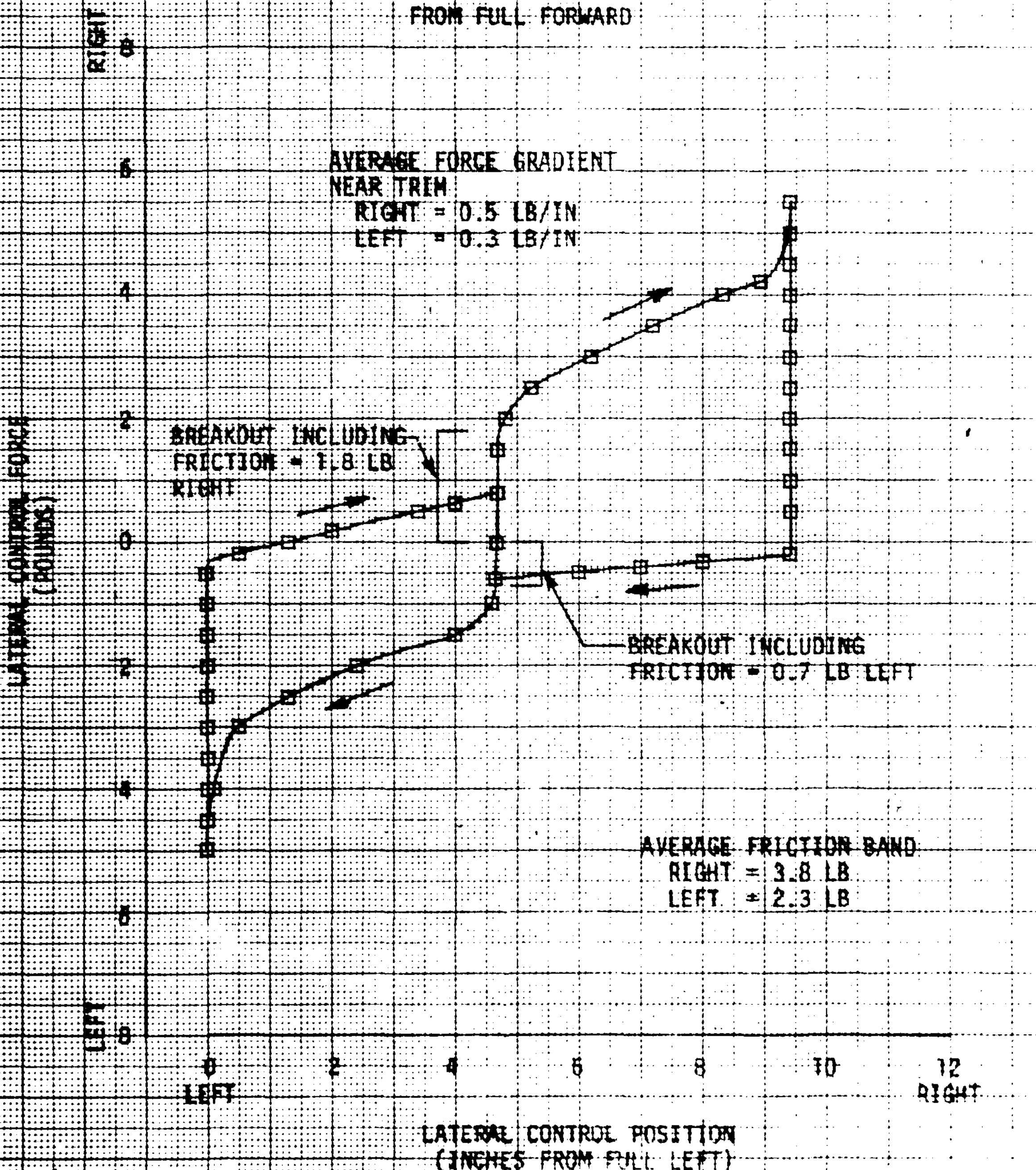


FIGURE 18
DIRECTIONAL CONTROL SYSTEM CHARACTERISTICS
YAH-64 USA S/N 74-22249

NOTES:
1. ROTORS STATIC
2. FORCES MEASURED AT THE DIRECTIONAL CONTROL
3. HYDRAULIC AND ELECTRICAL POWER PROVIDED BY GROUND POWER UNITS
4. HYDRAULIC FLIGHT CONTROL SYSTEM PRESSURIZED
5. AIRSPEED (Q) SENSOR PRESSURIZED
6. TOTAL DIRECTIONAL CONTROL TRAVEL = 5.39 INCHES

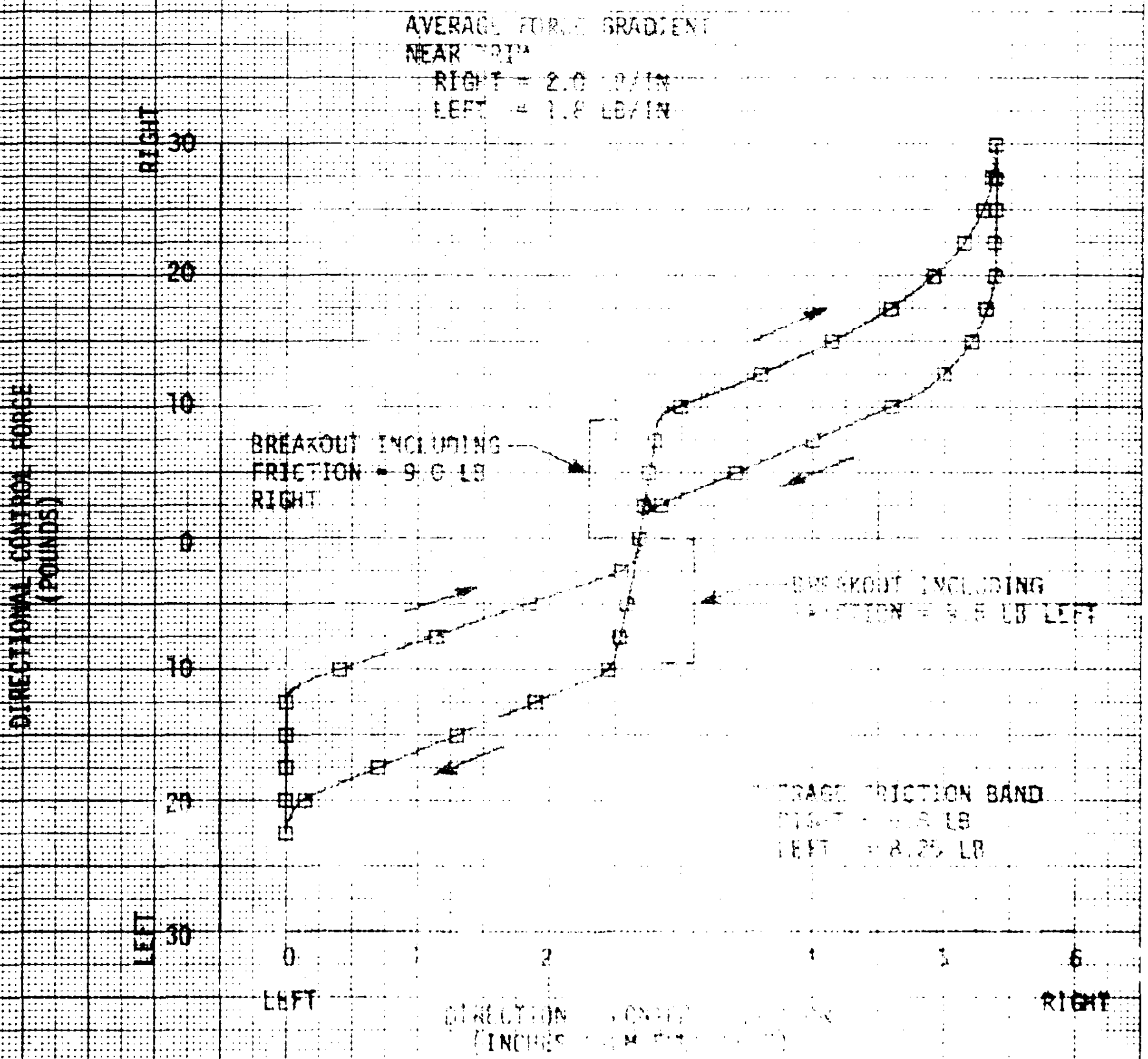
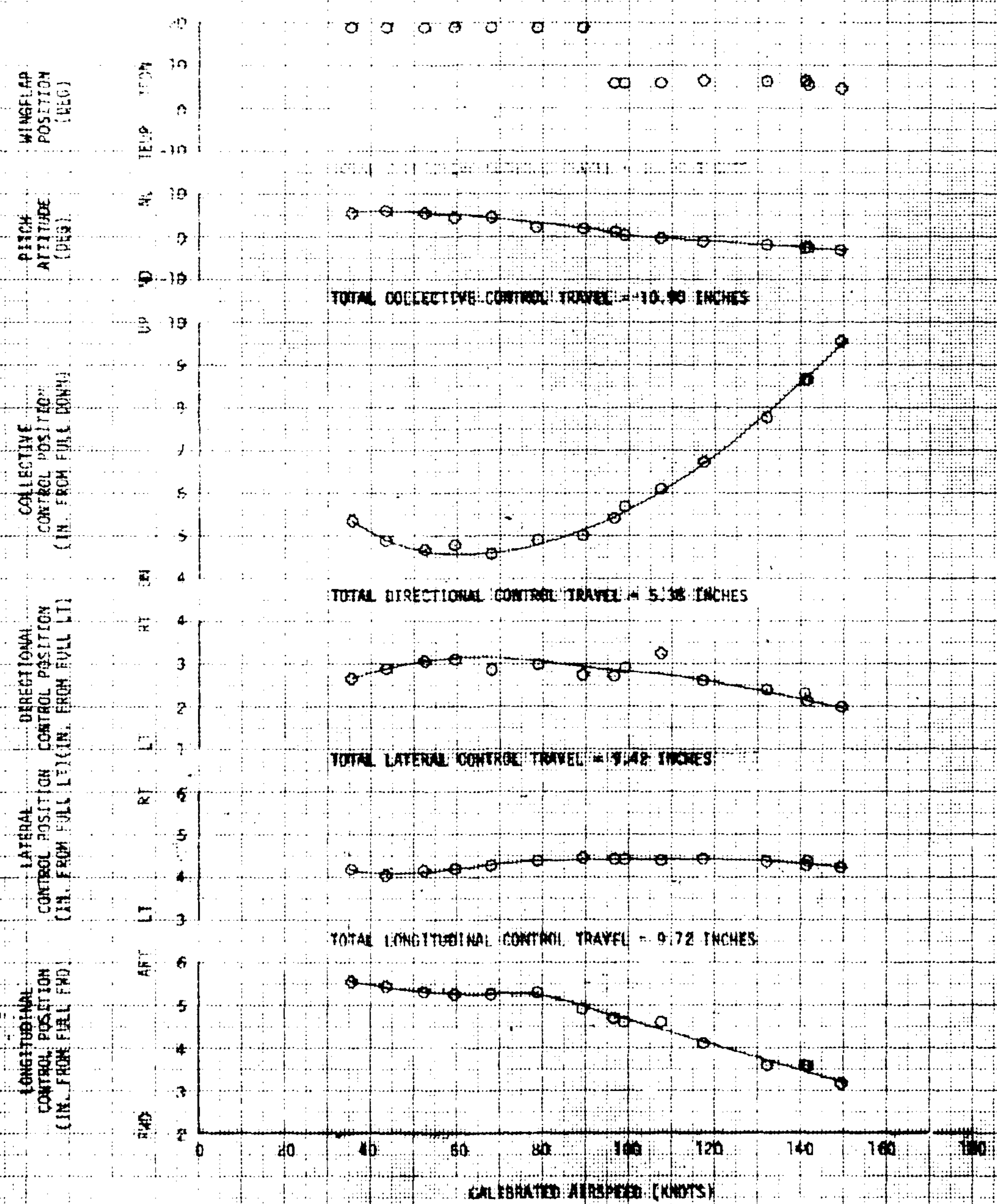


FIGURE 19
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
YAH-64 USA S/N 74-22249

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	AVG C_T	ASE CONDITION
14720	200.5(FWD)	-0.6 LT	2300	17.0	290	LVL FLT	0.006894	ON

NOTE: 8 HELLFIRE CONFIGURATION



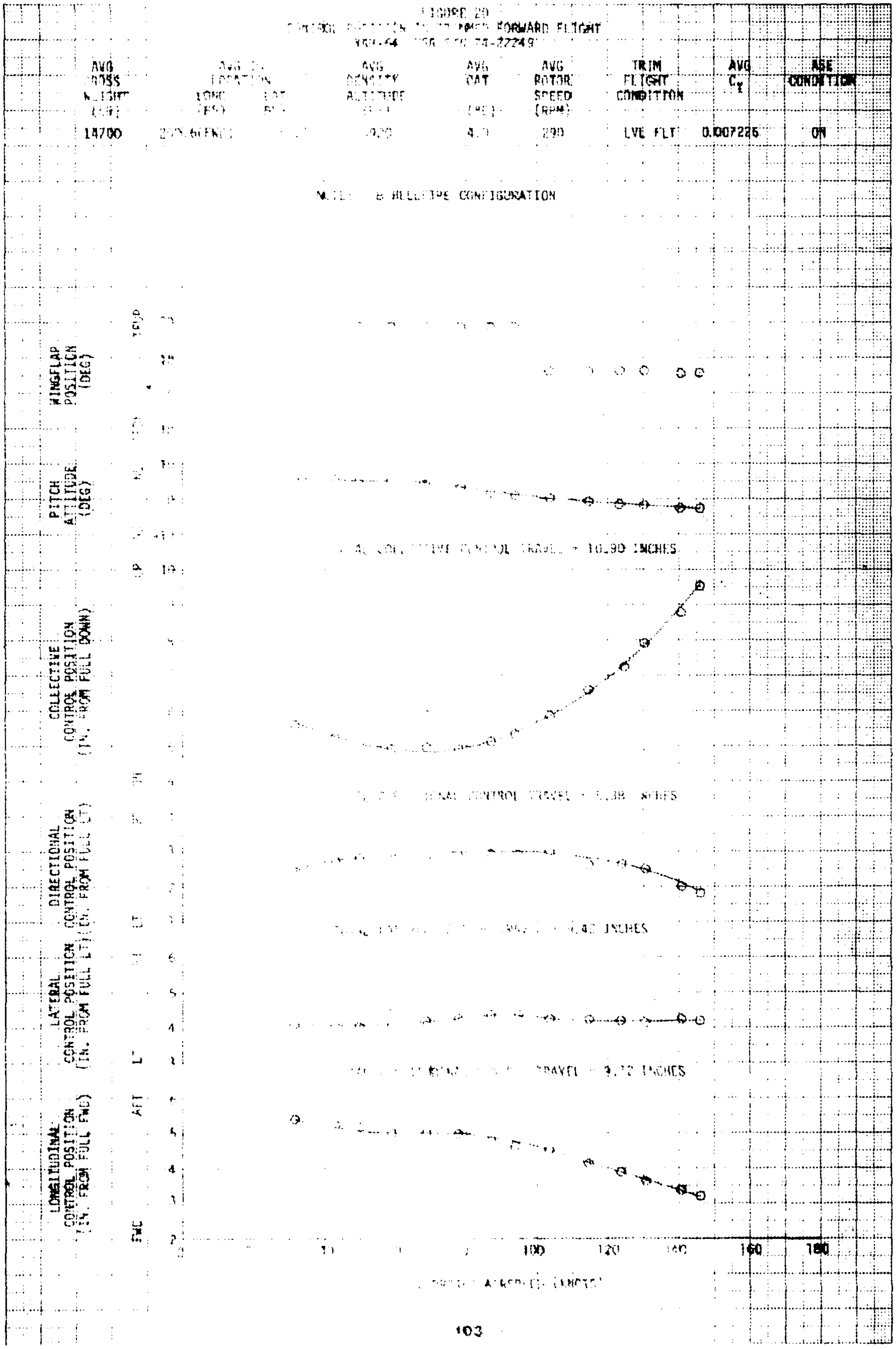

FORWARD FLIGHT
AVG GROSS WEIGHT
AVG DENSITY ALTITUDE
AVG OAT
AVG ROTOR SPEED (RPM)
TRIM FLIGHT CONDITION
AVG C_T
ASE CONDITION
14700
LVL FLT
0.007226
ON
CONFIGURATION
WINGFLAP POSITION (DEG)
PITCH ATTITUDE (DEG)
COLLECTIVE CONTROL POSITION (IN. FROM FULL DOWN)
DIRECTIONAL CONTROL POSITION (IN. FROM FULL LT)
LATERAL CONTROL POSITION (IN. FROM FULL LT)
LONGITUDINAL CONTROL POSITION (IN. FROM FULL FWD)
AFT
FWD
100
120
160
180

FIGURE 27
CONTROL POSITION IN TRIMMED FORWARD FLIGHT
YAH-64 USA S/N 74-22249

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	AVG C_T	ASE CONDITION
14680	200.3(FWD)	-0.6 LT	8280	12.5	290	LVL FLT	0.008249	ON

NOTE: 8 HELLFIRE CONFIGURATION

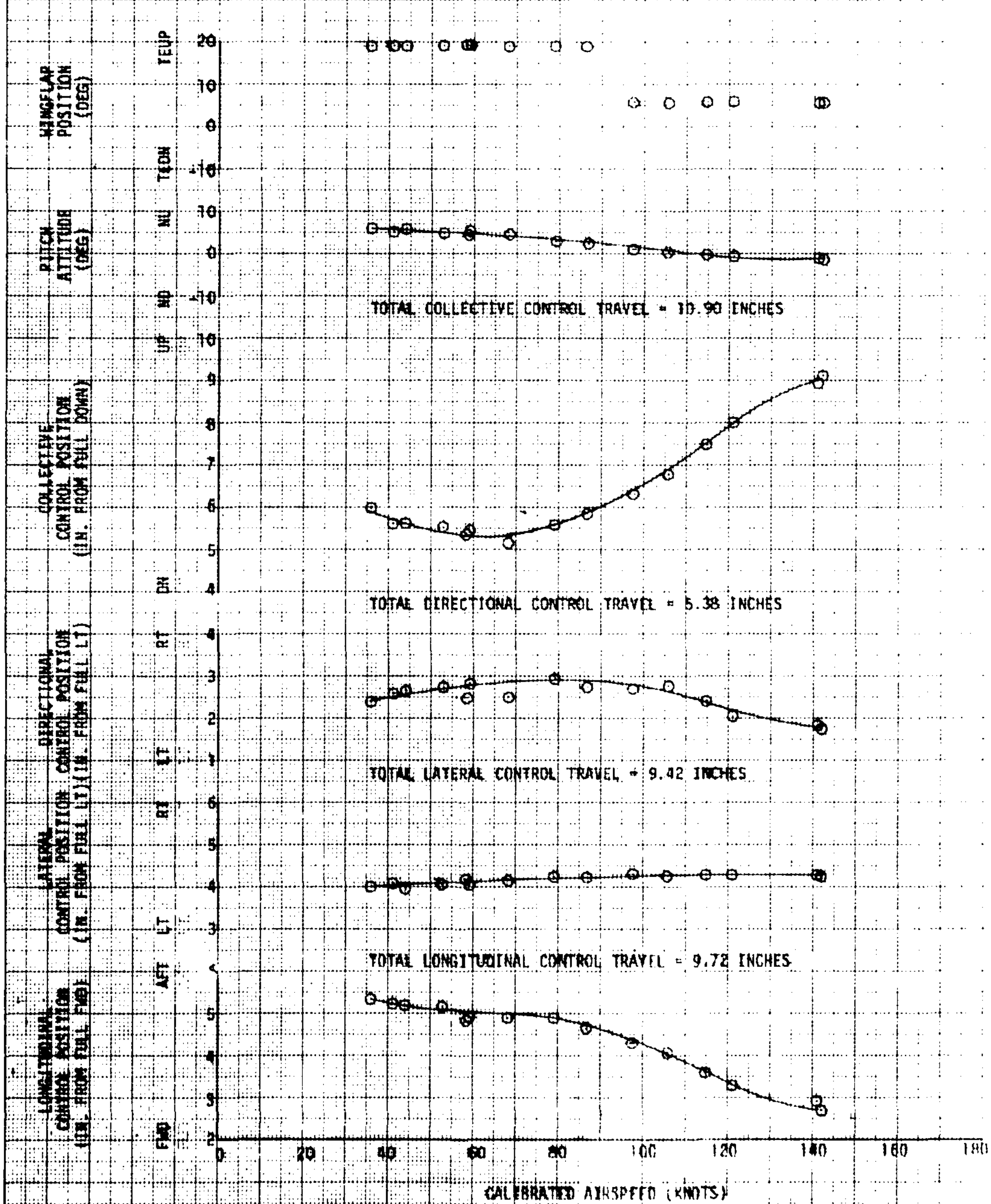


FIGURE 22
CONTROL POSITION IN TRIMMED FORWARD FLIGHT
YAH-64 USA S/N 74-22249

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	AVG C_T	ASE CONDITION
14760	200.9(FWD)	-0.5 LT	10960	7.5	290	LVL FLT	0.009098	ON

NOTE: 8 HELLFIRE CONFIGURATION

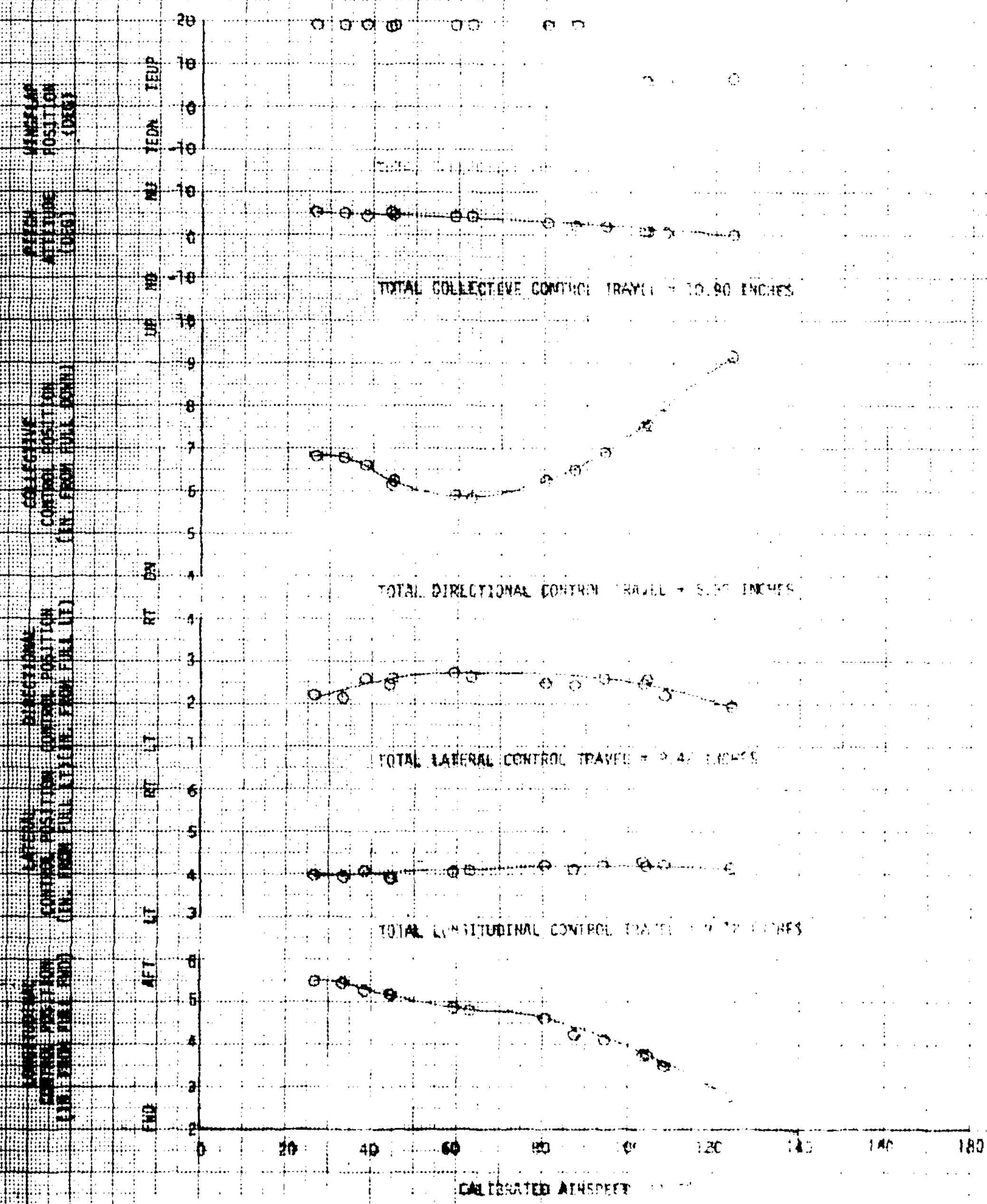


FIGURE 23
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
YAH-64 USA S/N 74-22248

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	ASE CONDITION
○	14060	20[illegible] (AFT)	-0.5 LT	5880	16.0	289	IRP CLIMB	ON
□	14200	206.6 (AFT)	-0.5 LT	5260	16.5	289	MIN POWER	ON

NOTE: 8 HELLFIRE CONFIGURATION

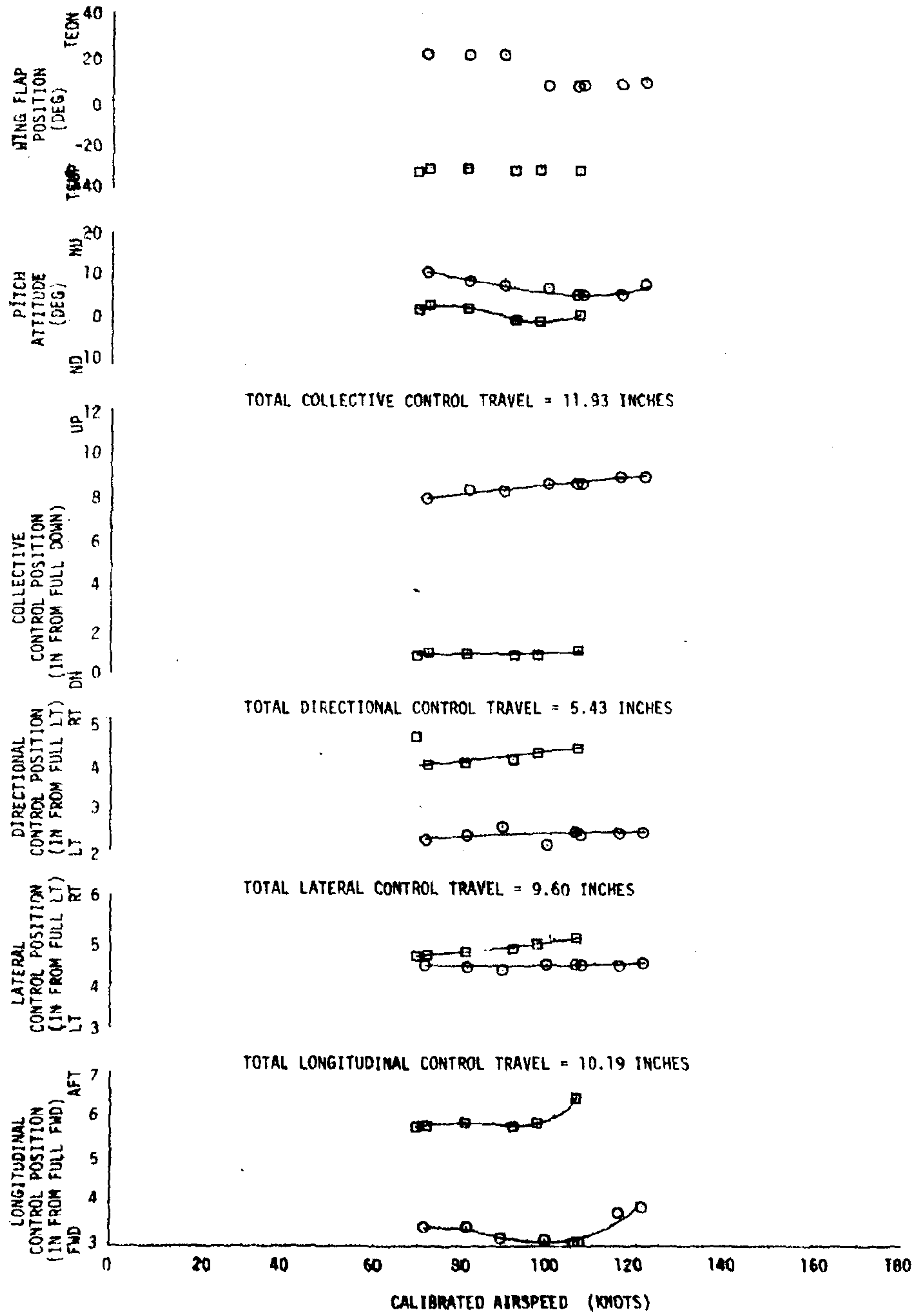


FIGURE 24
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
YAH-64 USA S/N 74-22248

AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	ASE CONDITION
14980	206.6(AFT)	-0.5LT	4760	17.5	289	LVL FLT	ON

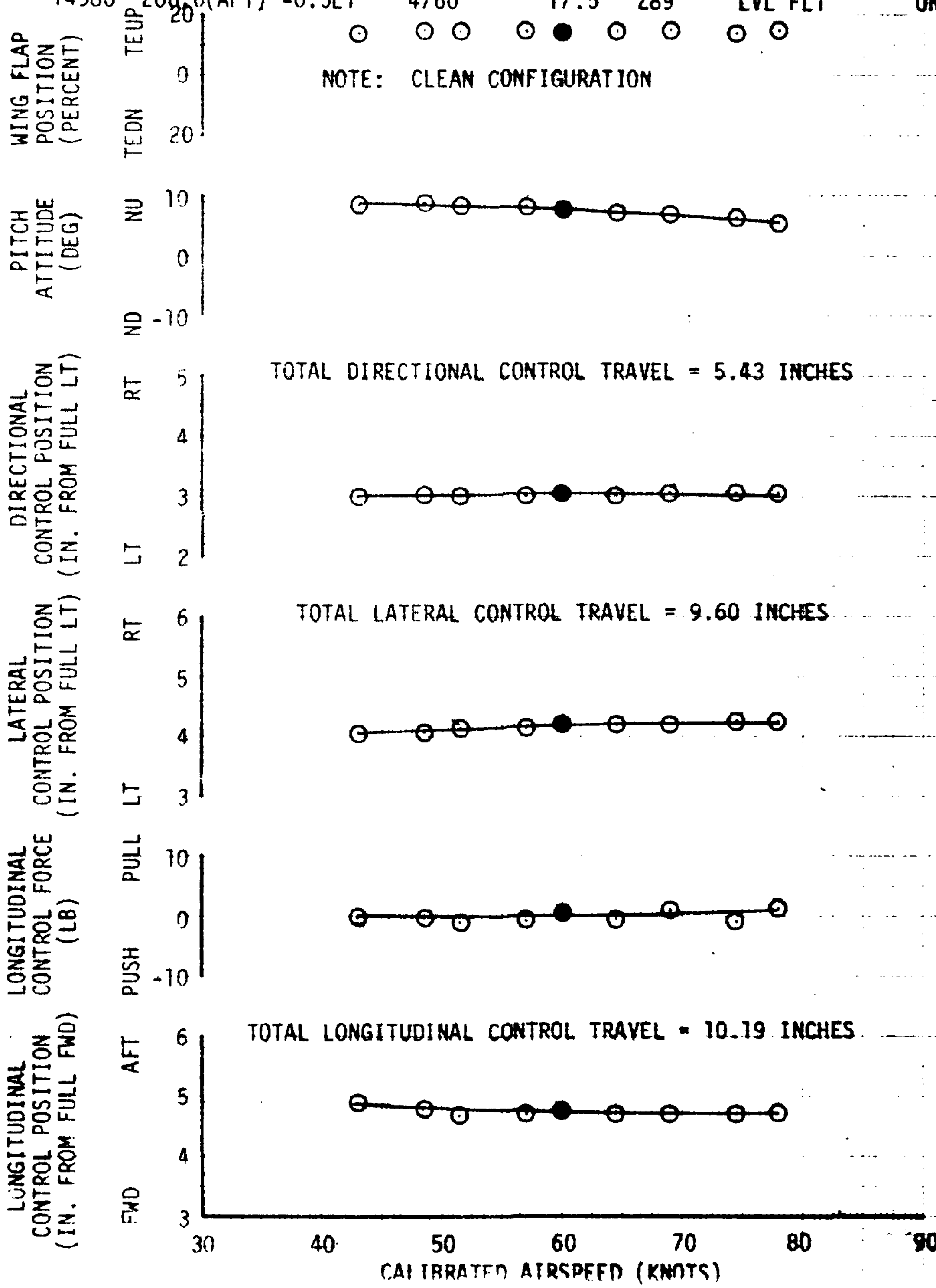


FIGURE 26
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
YAH-64 USA S/N 74-22248

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	TRIM FLIGHT CONDITION	ASE CONDITION
14520	206.5(AFT)	0.5LT	5460	15.0	289	LVL FLT	ON

NOTE: CLEAN CONFIGURATION

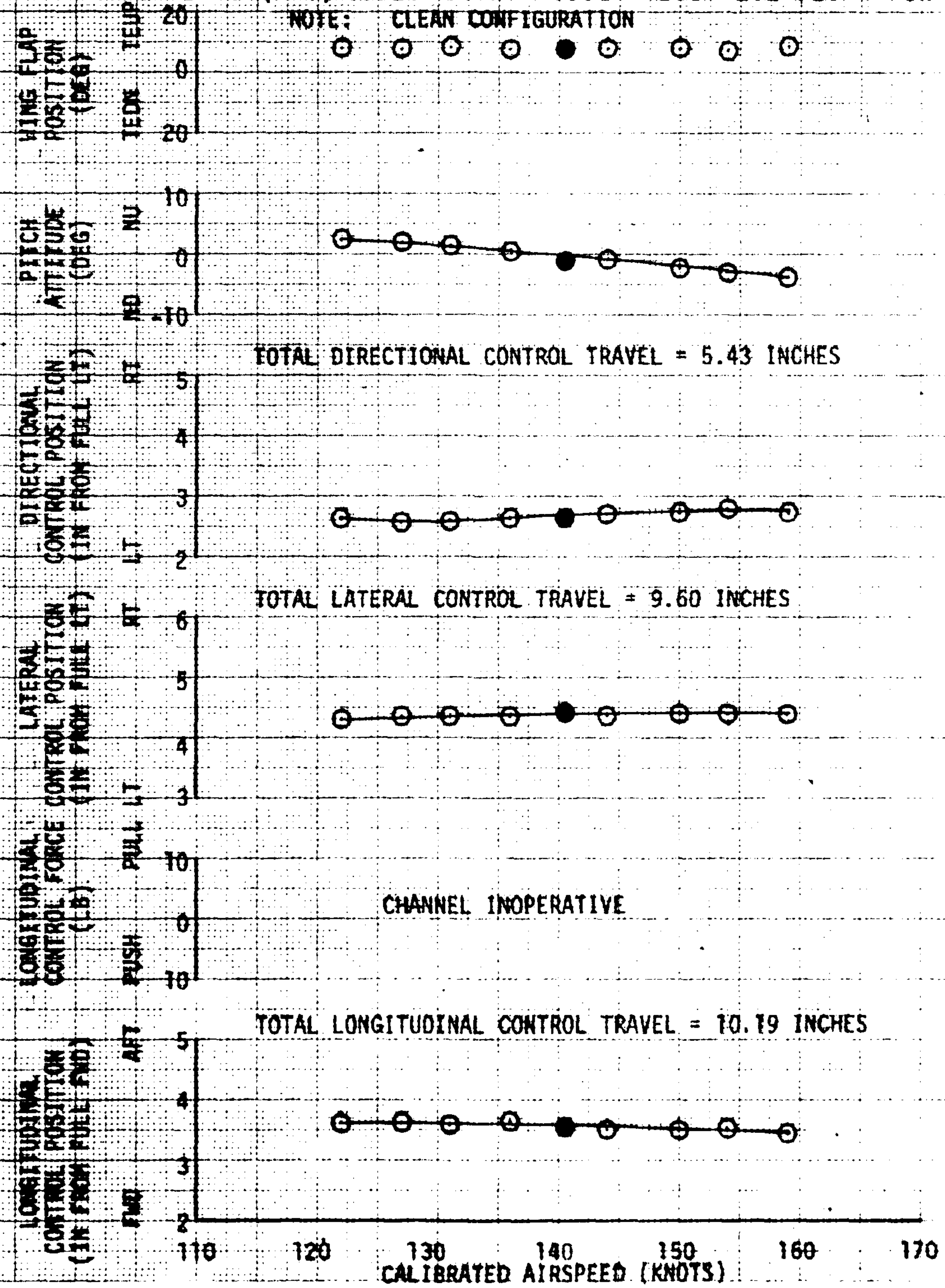


FIGURE 26
STATIC LATERAL-DIRECTIONAL STABILITY
YAH-64 USA S/N 74-22248

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (^{o}C)	AVG ROTOR SPEED (RPM)	TRIM CALIBRATED AIRSPEED (KCAS)	ASE CONDITION
14780	206.5(AFT)	-0.5LT	5180	17.0	289	59	ON

NOTE: CLEAN CONFIGURATION

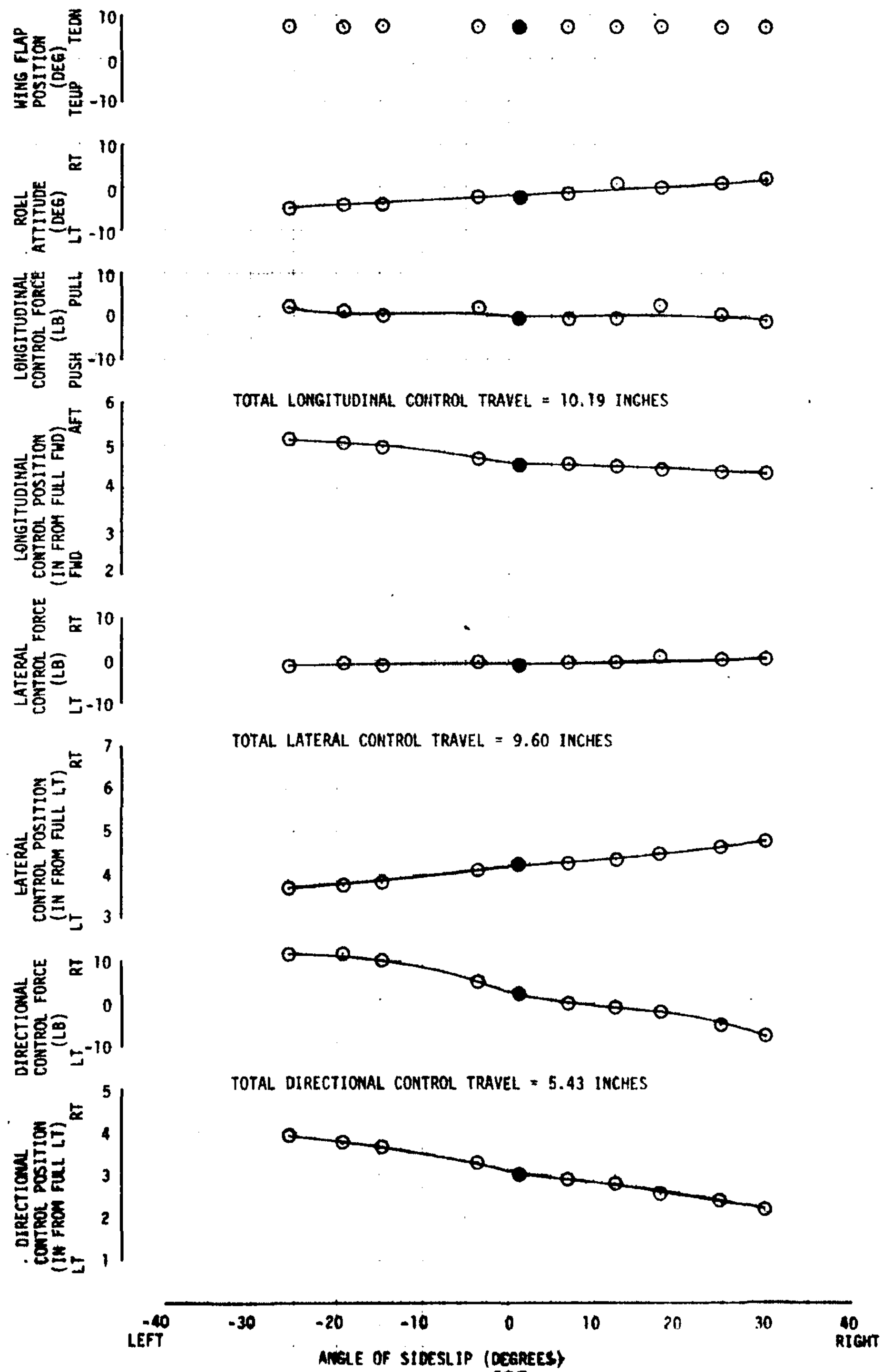


FIGURE 27
MANEUVERING STABILITY
YAH-64 USA S/N 74-22248

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	SAS CONDITION
○	13920	206.7(AFT)	-0.6LT	5180	14.5	289	RT TURN	ON
□	14120	206.6(AFT)	-0.5LT	5160	14.5	289	LT TURN	ON

NOTES: 1. CLEAN CONFIGURATION
2. 134 KCAS

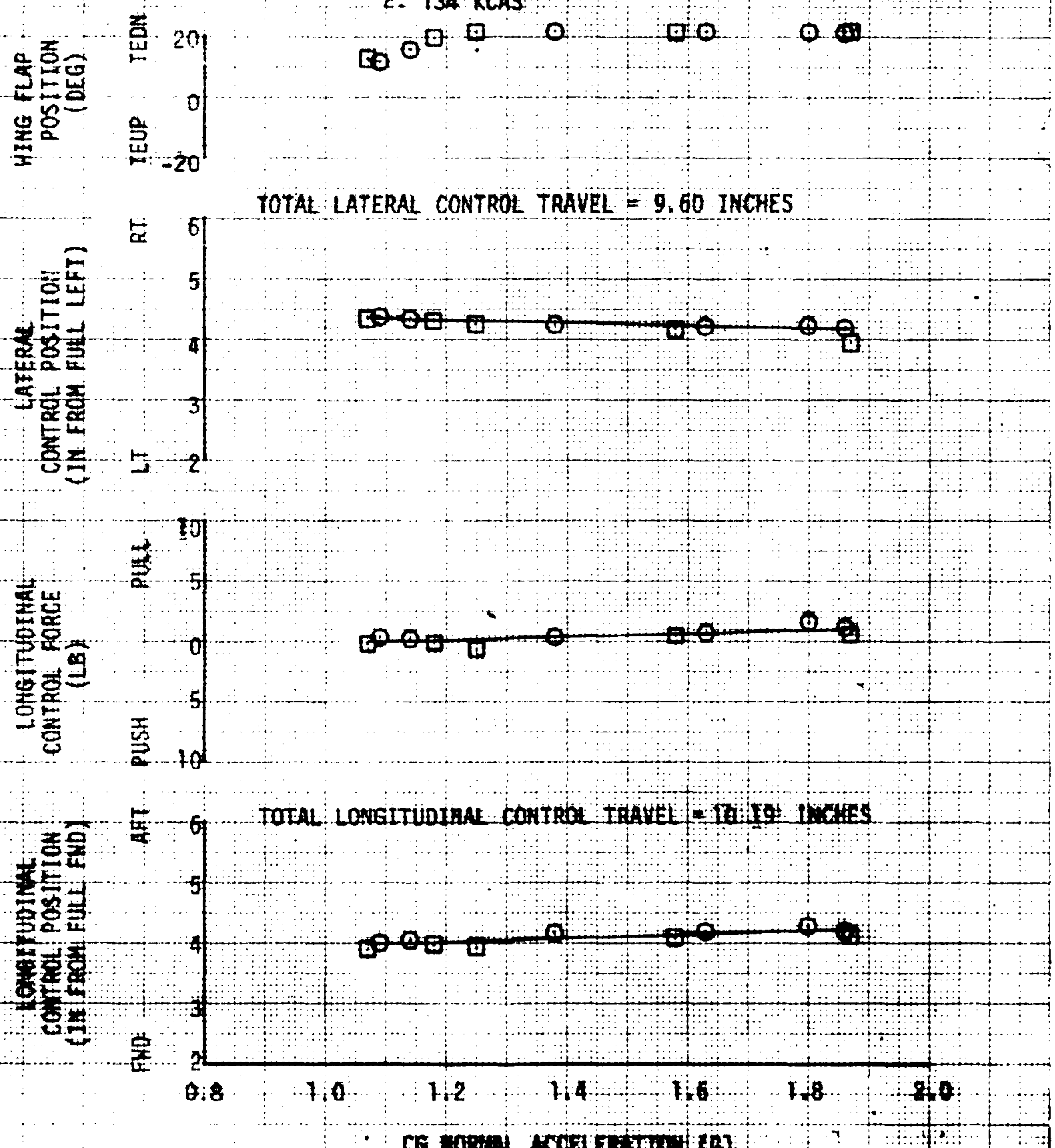


FIGURE 28

MANEUVERING STABILITY
SYMMETRICAL PUSHOVERS AND PULLUPS
YAH-64 USA S/N 74-22248

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (^{o}C)	AVG ROTOR SPEED (RPM)	SCAS CONDITION
13800	206.8 (AFT)	0.6 LT	5200	14.5	289	ON

NOTES: 1. CLEAN CONFIGURATION
2. STICK MOVEMENT AT 134 KCAS

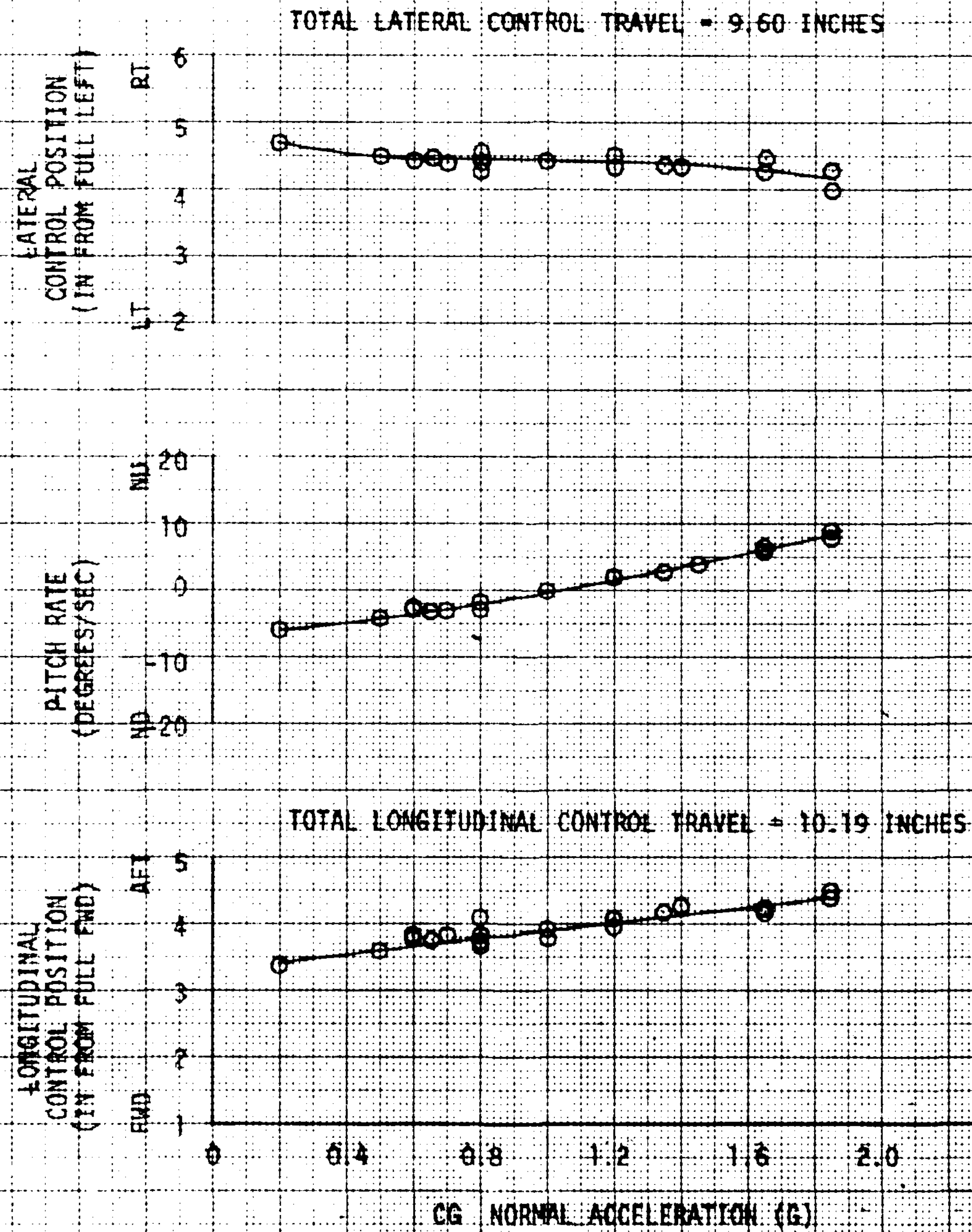


FIGURE 29
LATERAL DOUBLET
YAH-64 USA S/N 74-22248

AVG GROSS WEIGHT	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG CALIBRATED AIRSPEED (KT)	ASE CONDITION
14,960	206.8(AFT)	-0.5 LT	4920	16.0	289	125	OFF

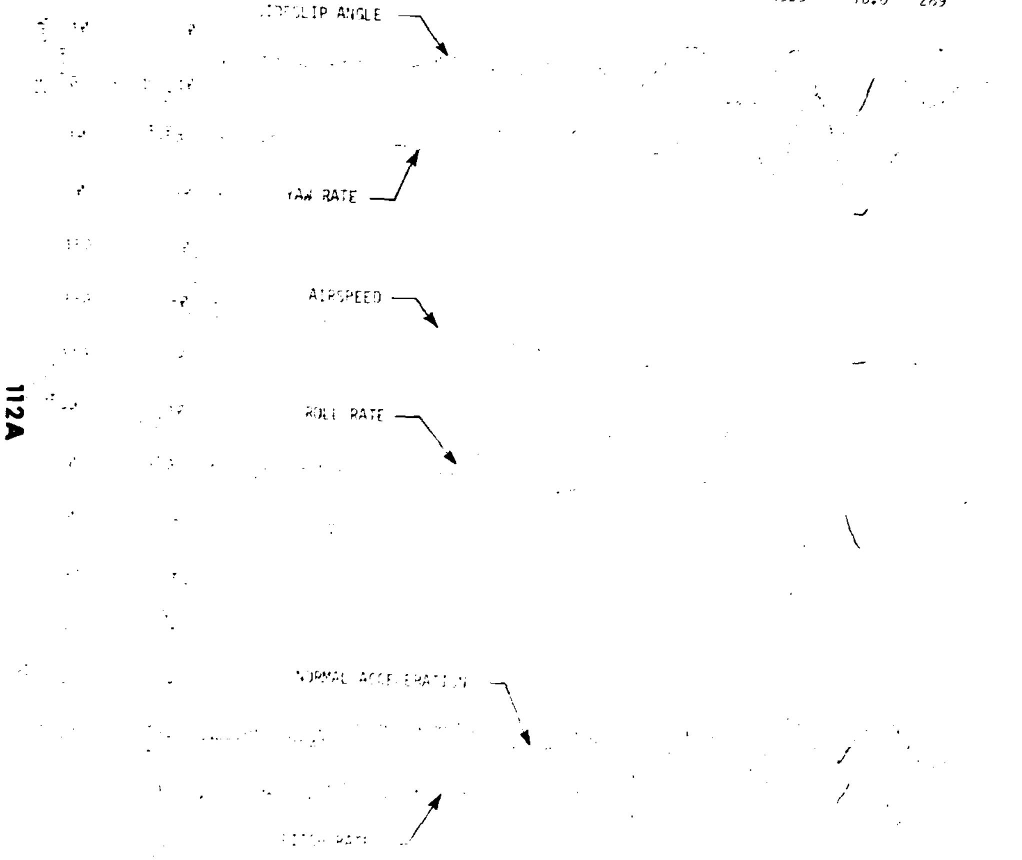


FIGURE 29 (CONT)

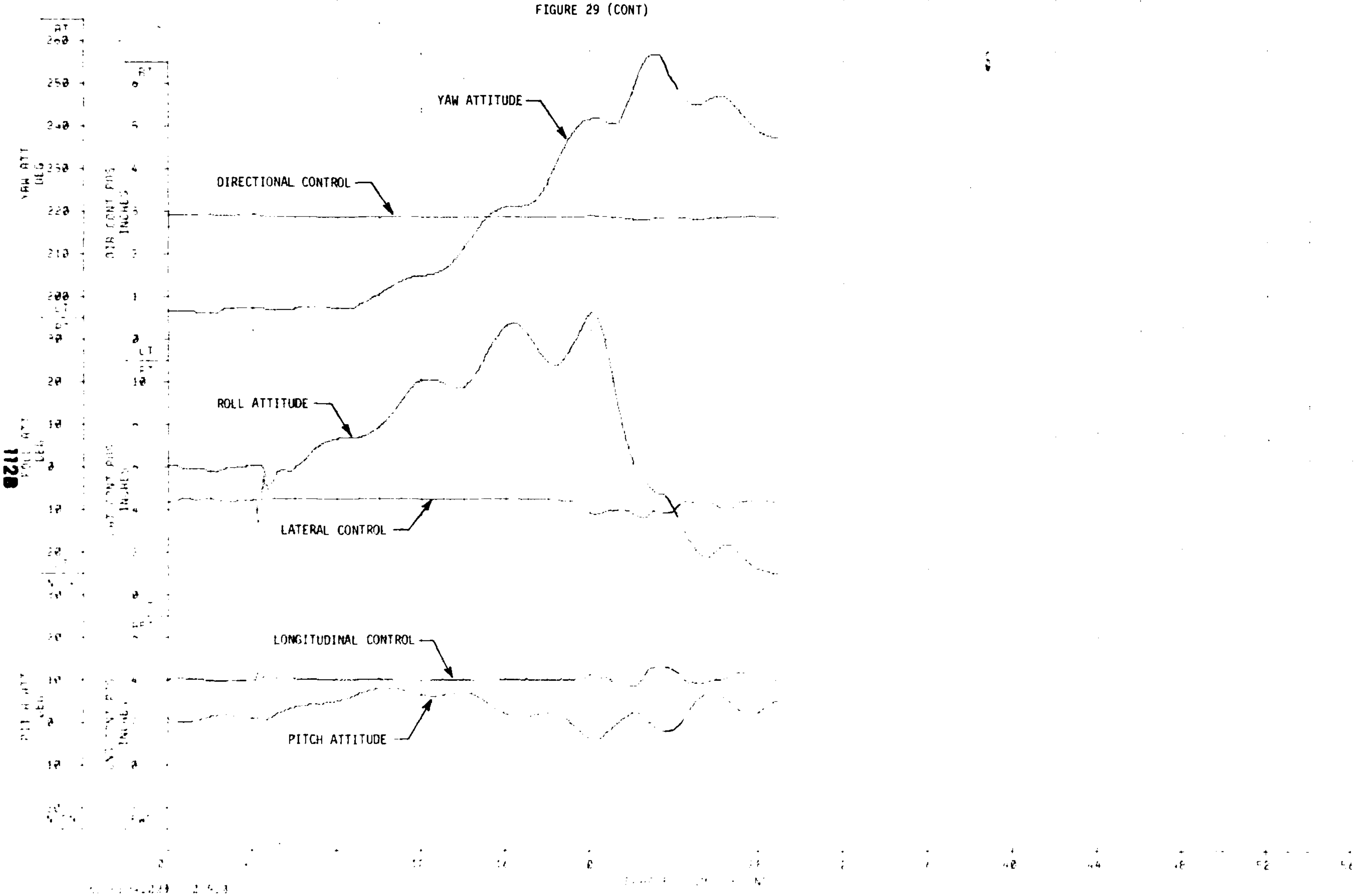


FIGURE 30
ASE DISENGAGEMENT
YAH-64 USA S/N 74-22248

AVG GROSS WEIGHT	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	AVG CALIBRATED AIRSPEED (KT)	ASE CONDITION
14,860	206.7(AFT)	-0.5 LT	4940	15.5	290	136	OFF

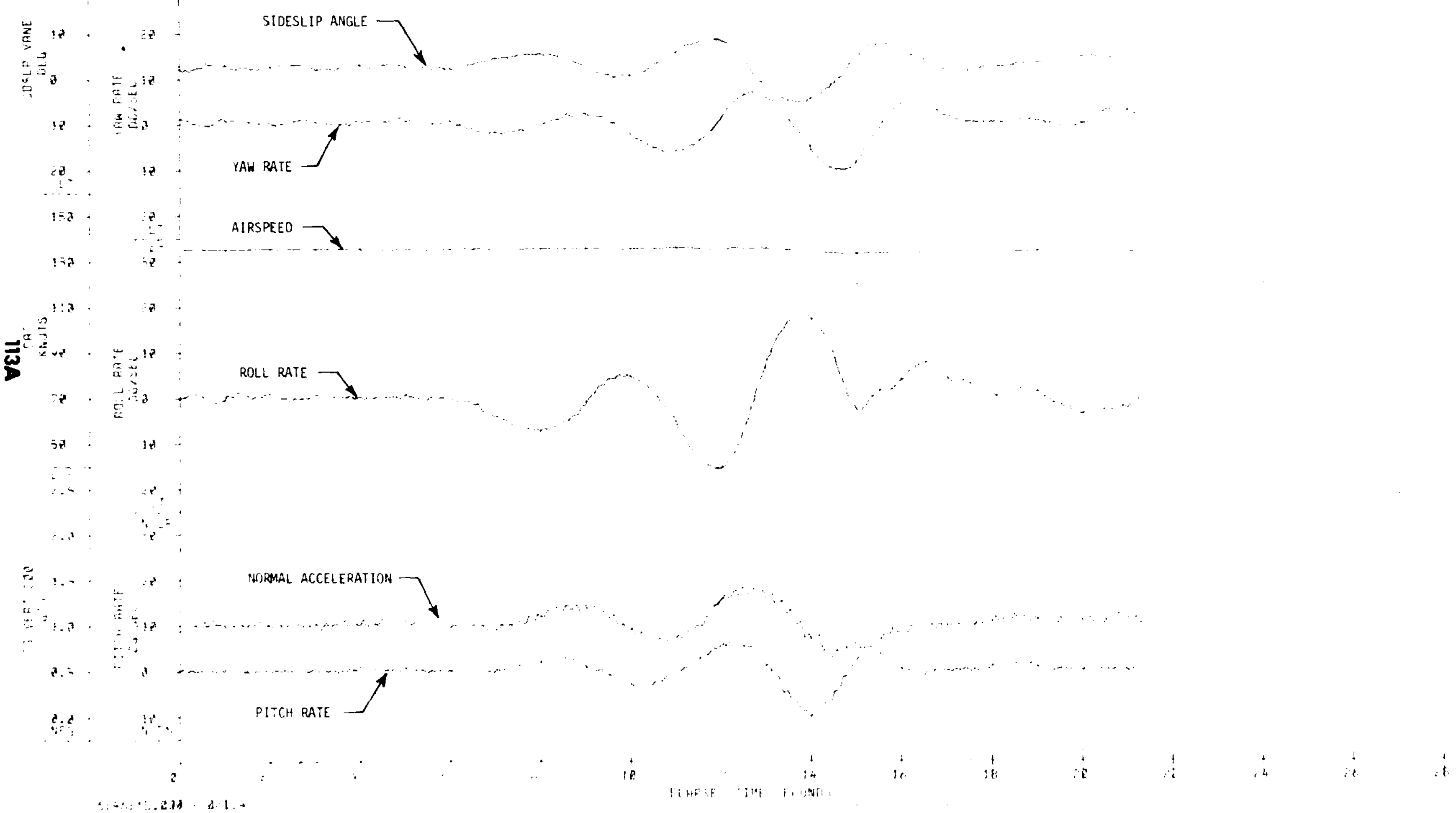


FIGURE 30 (CONT)

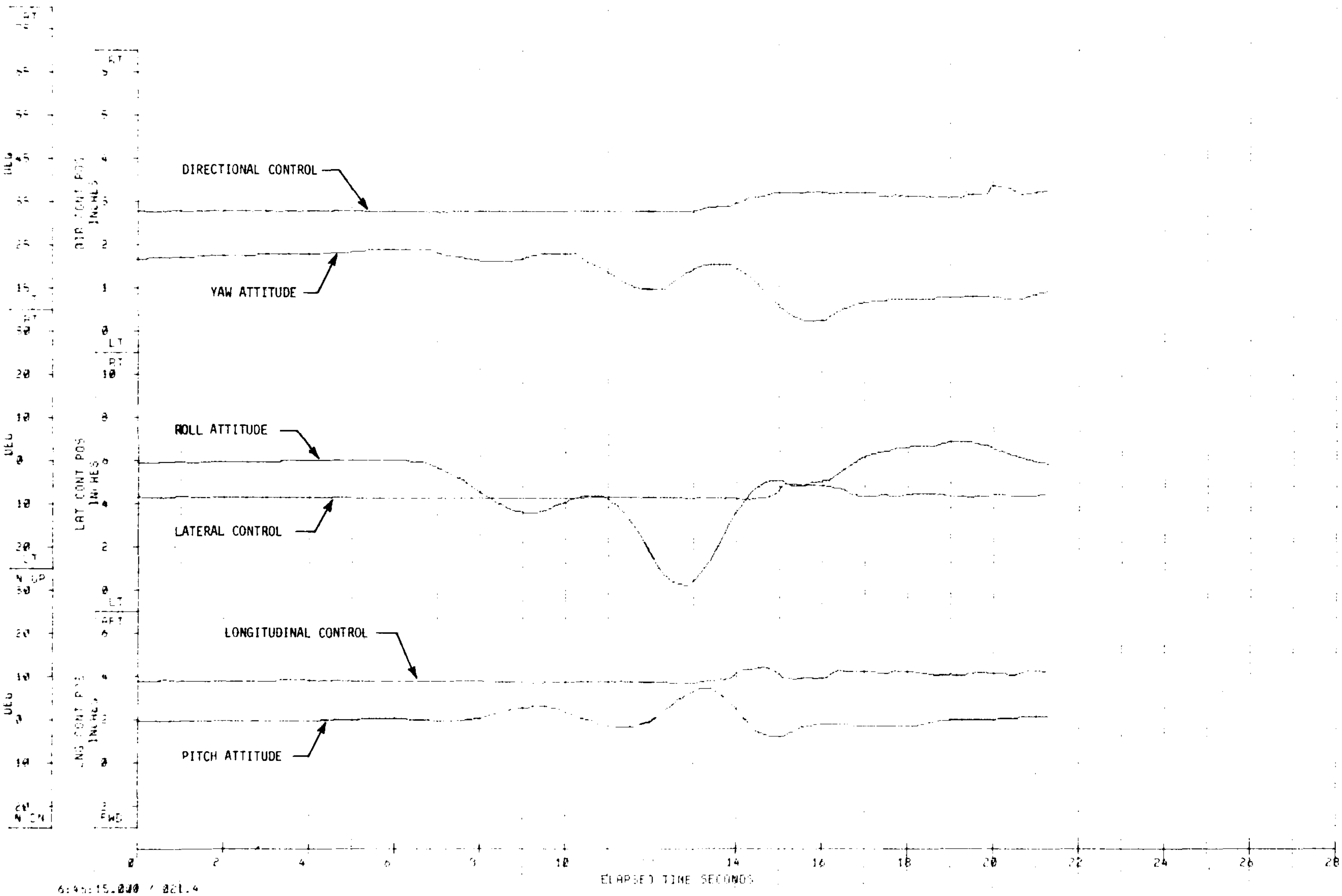


FIGURE 37

PITCH COUPLED DUTCH ROLL RATE DAMPING

YAH-64 USA S/N 74-22248

AVG GROSS WEIGHT (LBS)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT ($^{\circ}C$)	AVG ROTOR SPEED (RPM)	SAS/ASE CONDITION
13680	206.8 (AFT)	0.6 LT	5200	14.5	289	OFF

NOTE: CLEAN CONFIGURATION

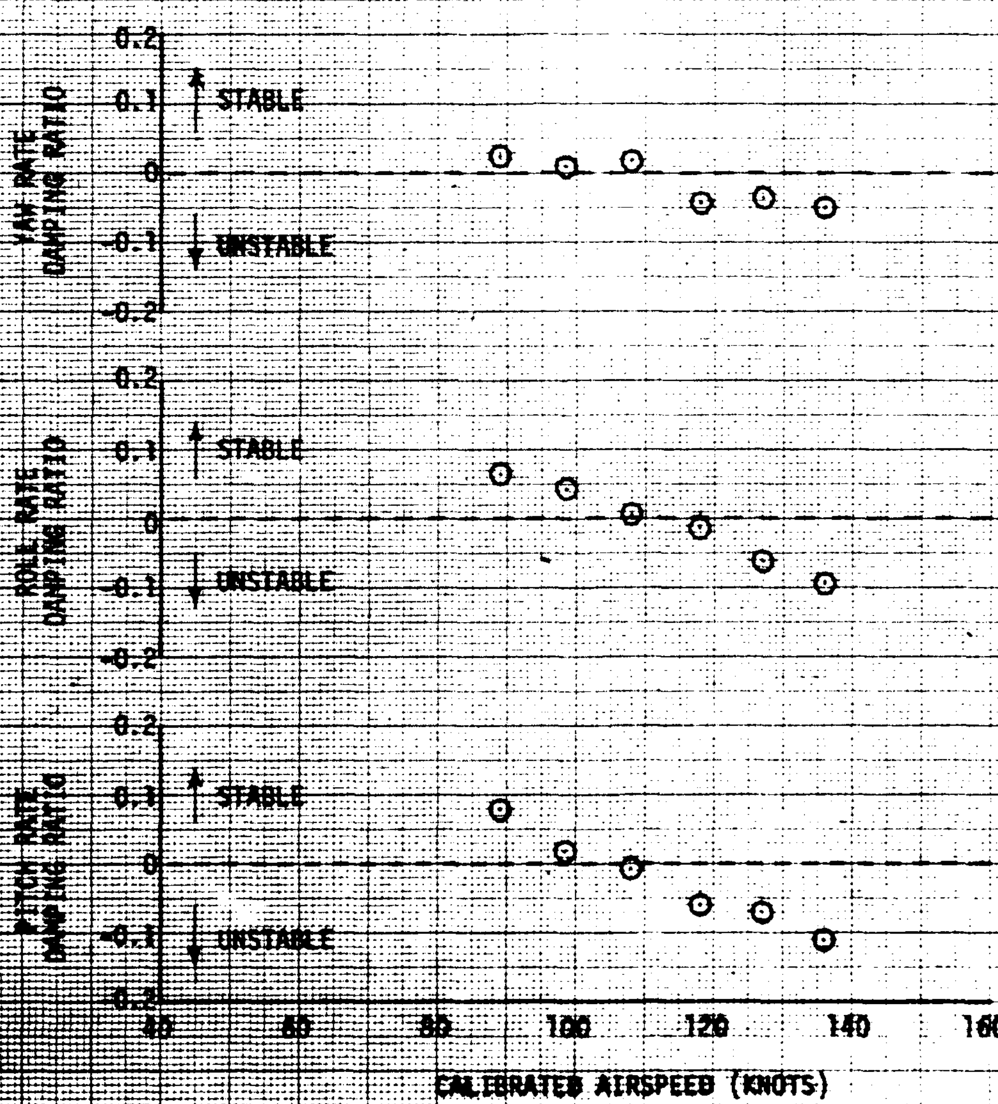


FIGURE 32
TAKEOFF
YAH-64 USA S/N 74-22248

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	CONFIGURATION	ASE CONDITION
15,860	200.6(FWD)	-0.5 LT	420	16	289	CLEAN	ON

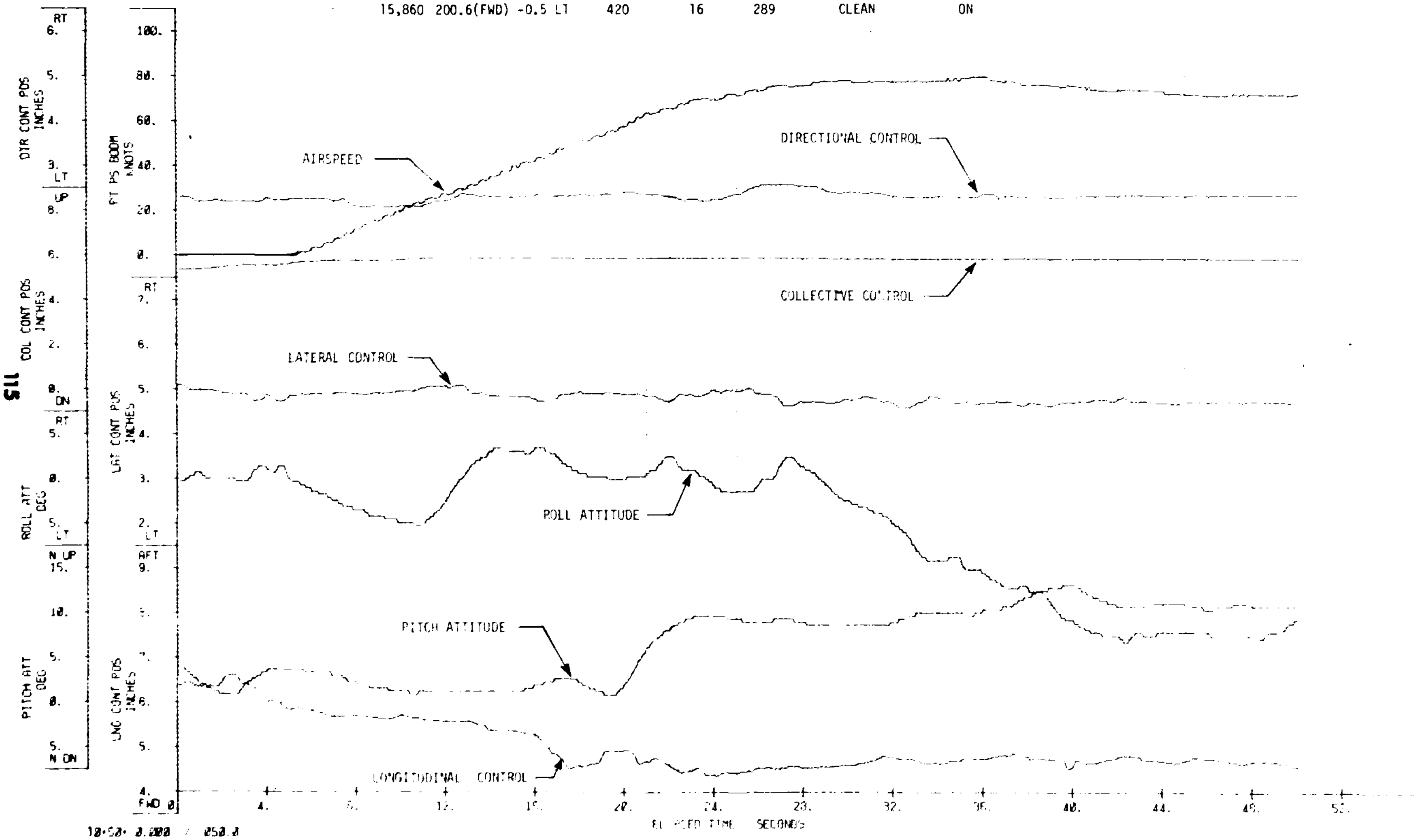


FIGURE 33
LANDING
YAH-64 USA S/N 74-22248

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	CONFIGURATION	ASE CONDITION
14,600	200.2(FWD)	-0.6 LT	260	13	289	CLEAN	ON

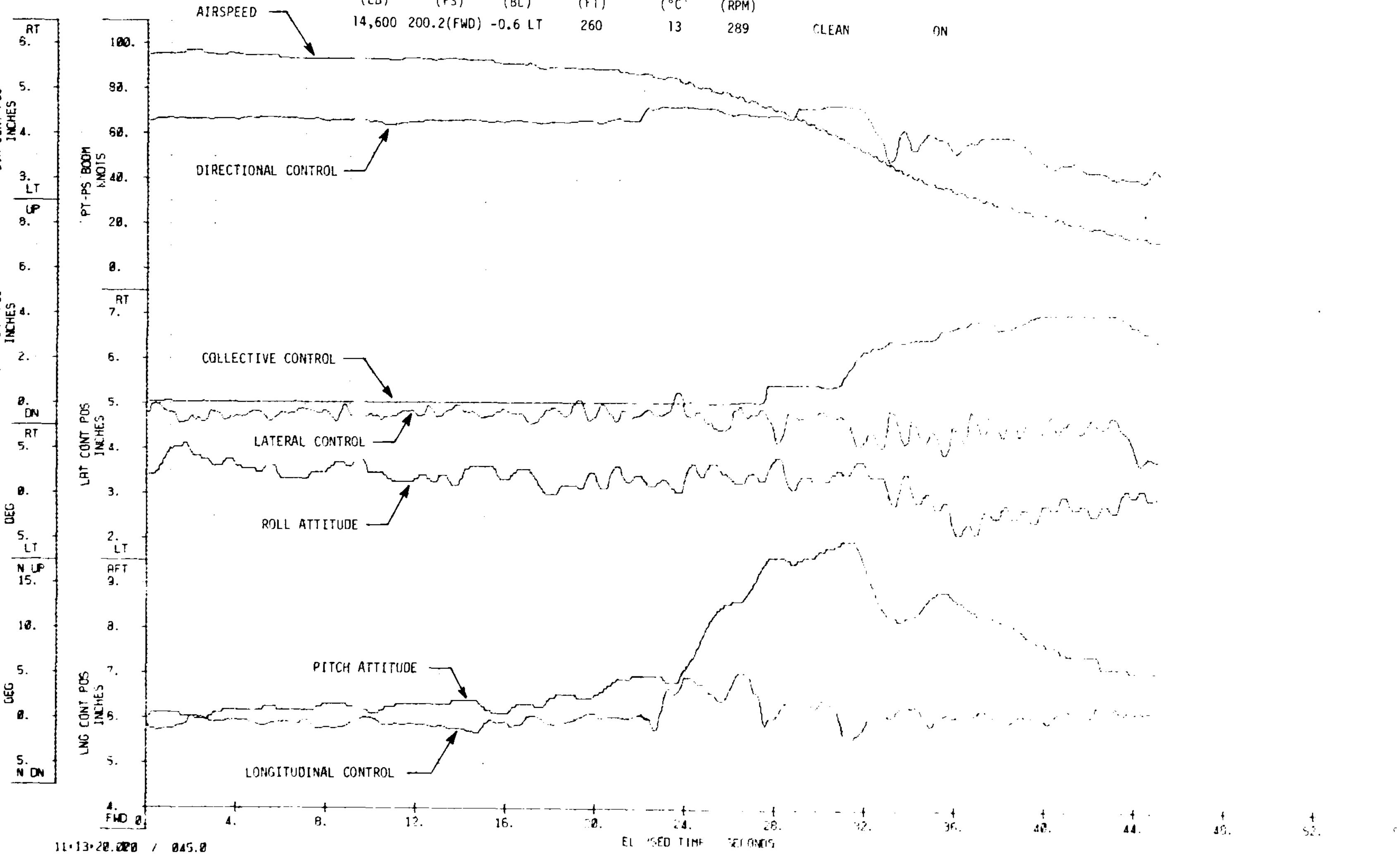


FIGURE 34
SIDEWARD FLIGHT
YAH-64 USA S/N 74-22249

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	WHEEL HEIGHT (FT)	[redacted] CONDITION
15180	200.0(FWD)	-0.5LT	140	11.0	289	15	ON

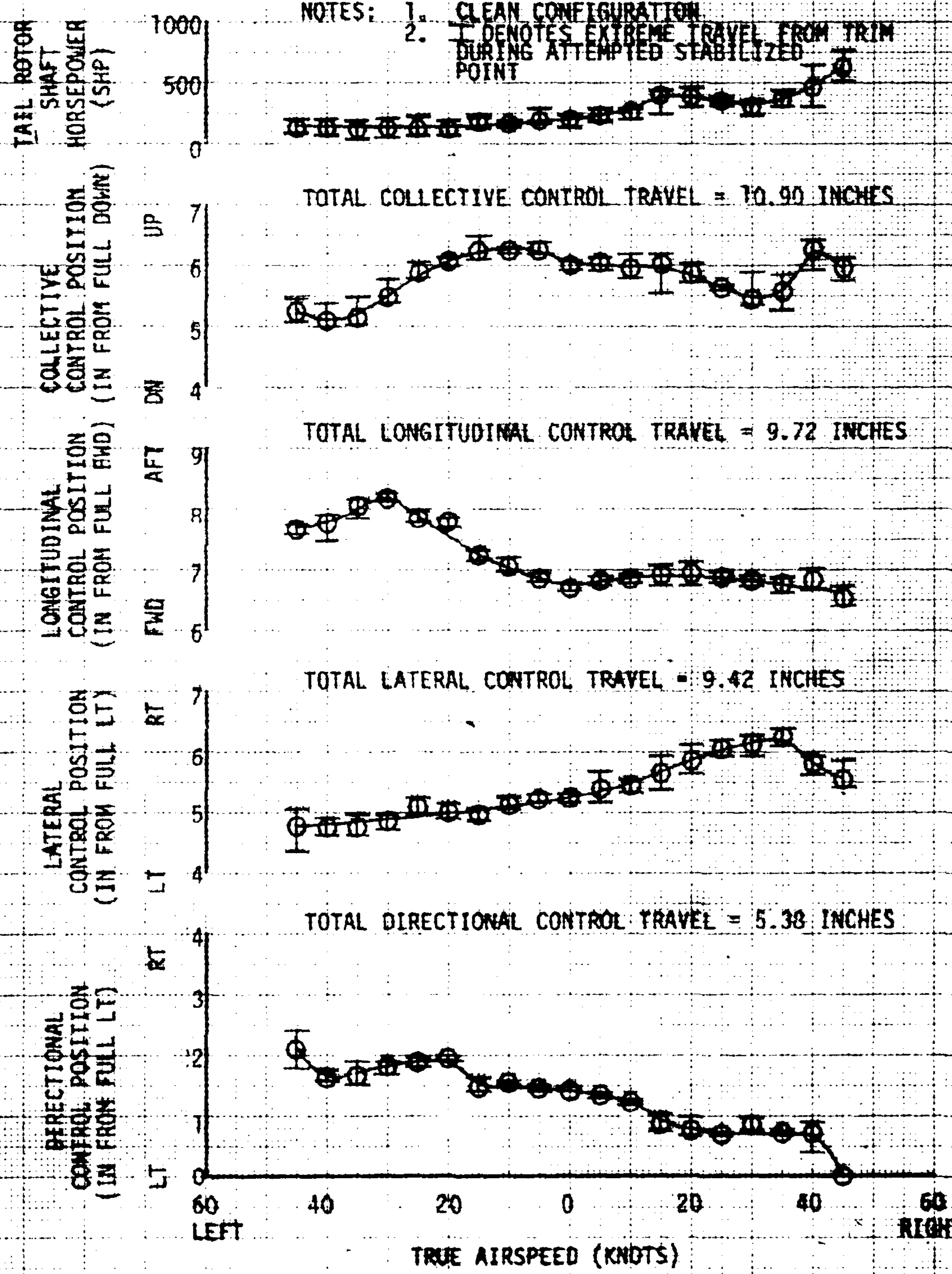


FIGURE 35
SIDEWARD FLIGHT
YAH-64 USA S/N 74-22249

AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	WHEEL HEIGHT (FT)	ASE CONDITION
15040	205.4 (AFT)	-0.6LT	360	13.0	289	15	ON

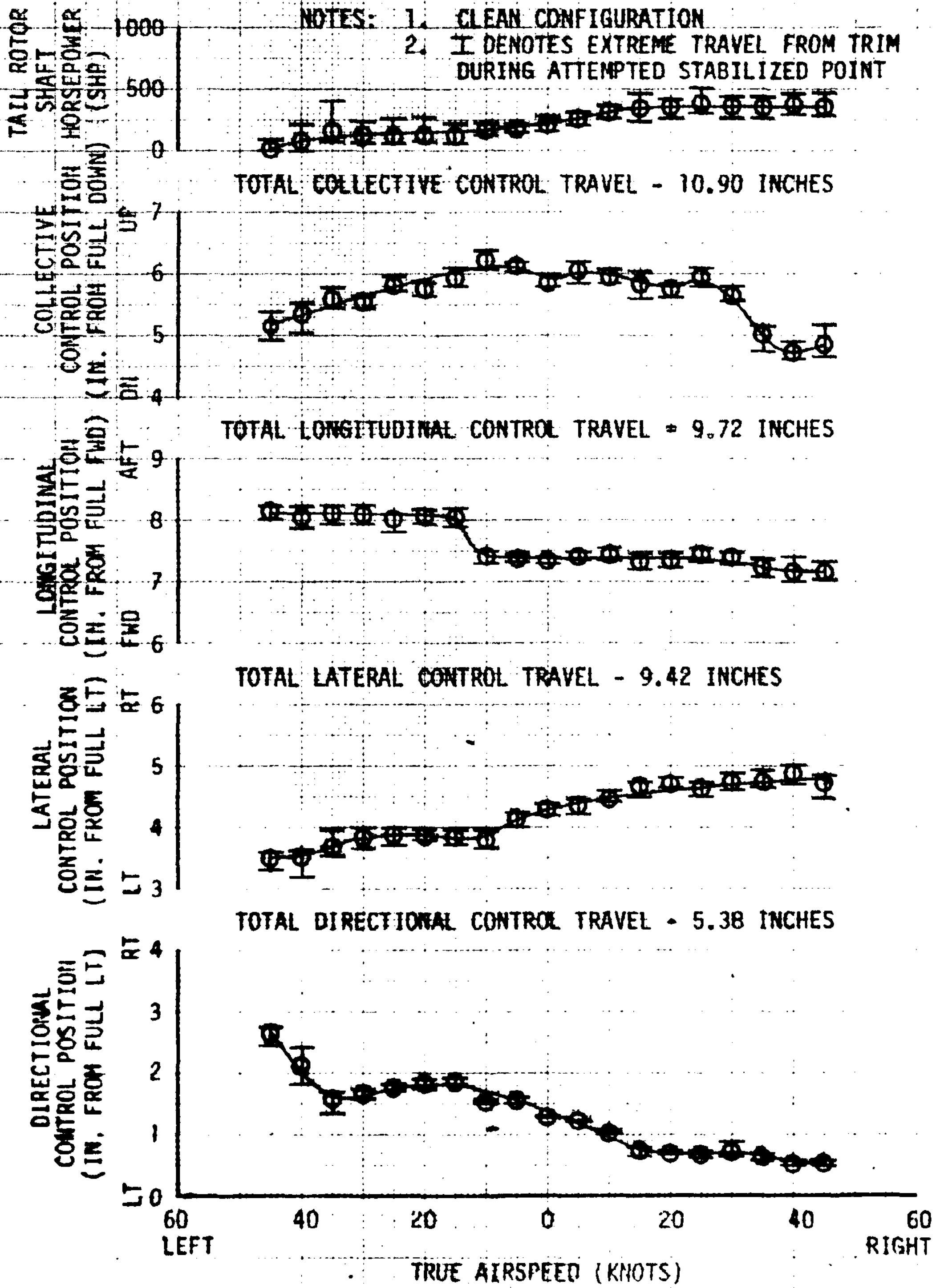


FIGURE 36
SIDEWARD FLIGHT
YAH-64 USA S/N 74-22249

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BG)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	WHEEL HEIGHT (FT)	ASE CONDITION
14700	199.7 (FWD)	-0.6 LT	160	11.0	289	15	OFF

NOTES: 1. CLEAN CONFIGURATION
2. I DENOTES EXTREME TRAVEL FROM TRIM DURING ATTEMPTED STABILIZED POINT

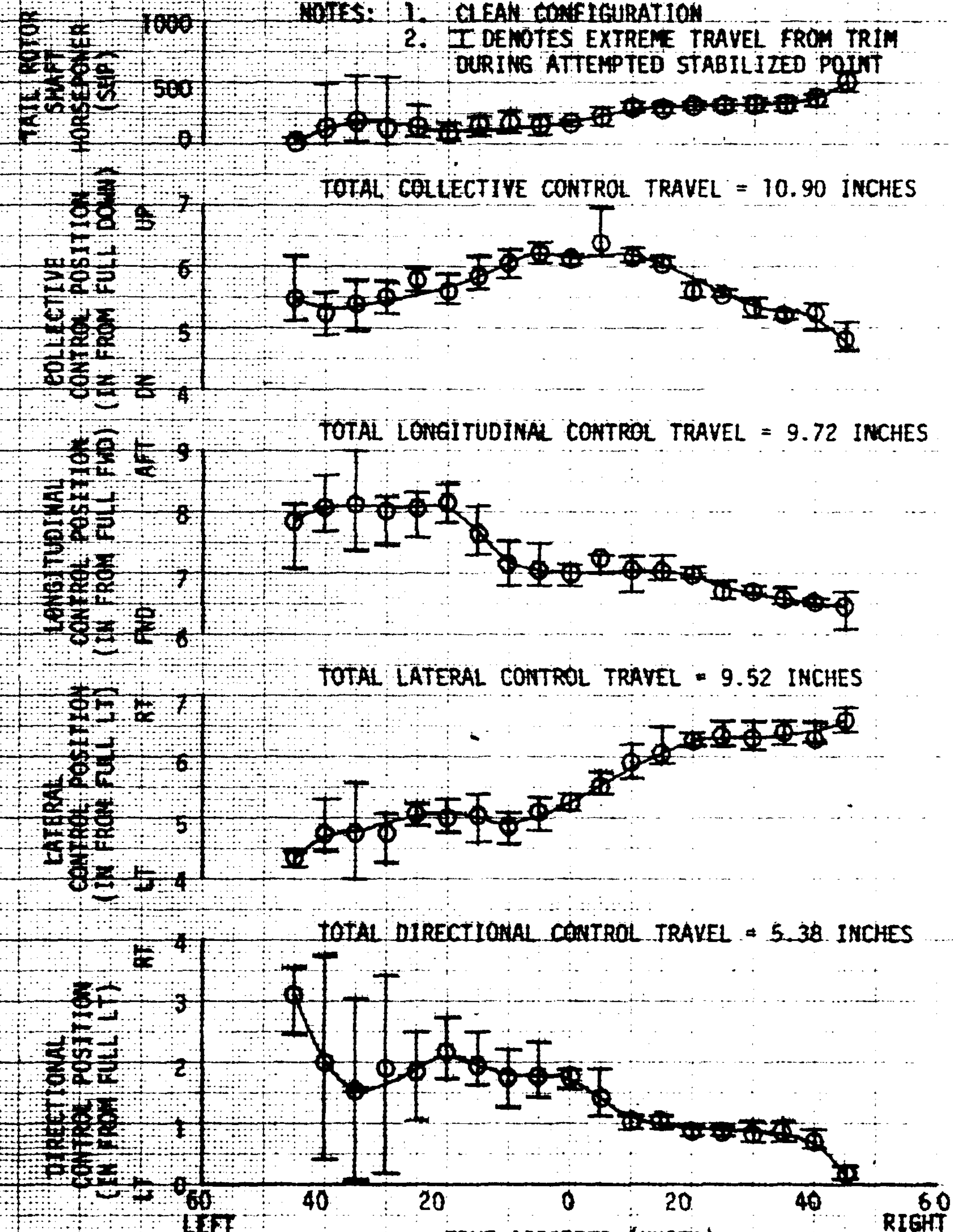


FIGURE 37
SIDEWARD FLIGHT
YAH-64 USA S/N 74-22249

AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	WHEEL HEIGHT (FT)	ASE CONDITION
14,700	205.5(AFT)	-0.6LT	480	14.0	289	15	OFF

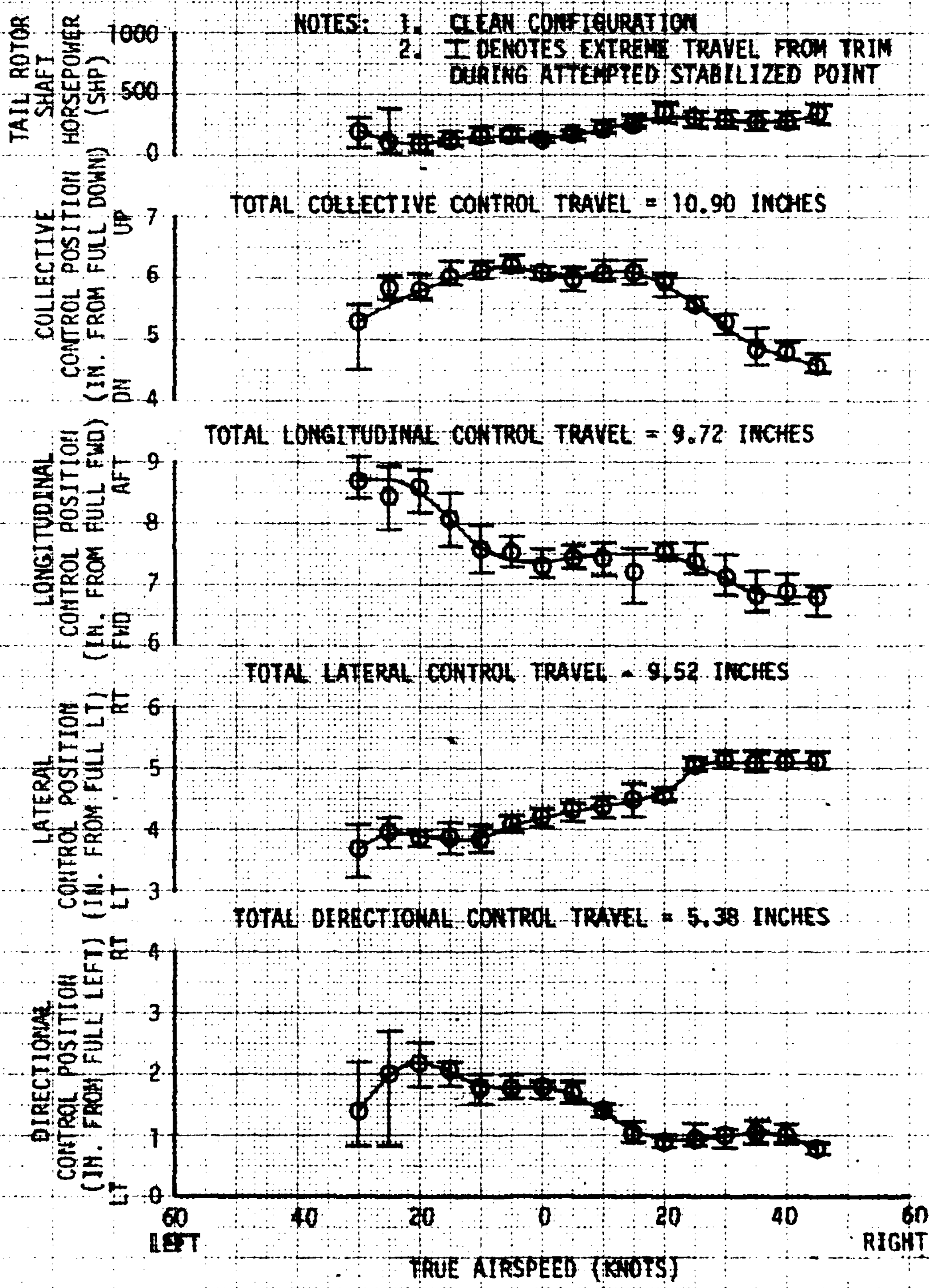


FIGURE 35
CRITICAL AZIMUTH
YAH-64 USA S/N 74-22249

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	WHEEL HEIGHT (FT)	TRIM TRUE AIRSPEED (KTS)	ASE CONDITION
14700	200.1(FWD)	0.6LT	[illegible]	13.0	289	15	30	ON

NOTES: 1. CLEAN CONFIGURATION
2. I DENOTES EXTREME TRAVEL FROM TRIM DURING ATTEMPTED STABILIZED POINT

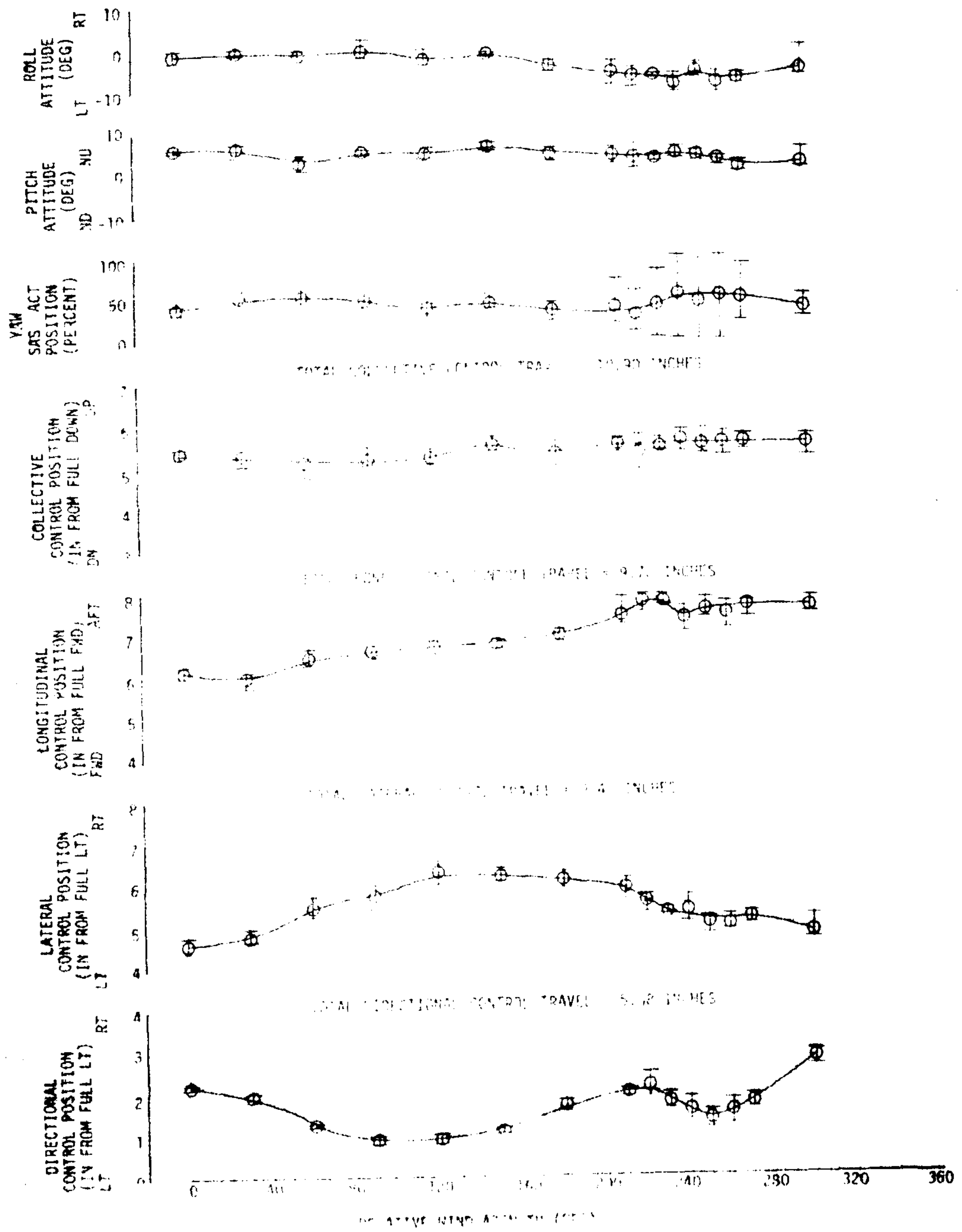


FIGURE 39
SIDEWARD FLIGHT
YAH-64 USA S/N 74-22248
CRITICAL AZIMUTH 250 DEGREES

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	WHEEL HEIGHT (FT)	ASE CONDITION
15860	200.6(FWD)	0.6LT	420	16.0	289	15	ON

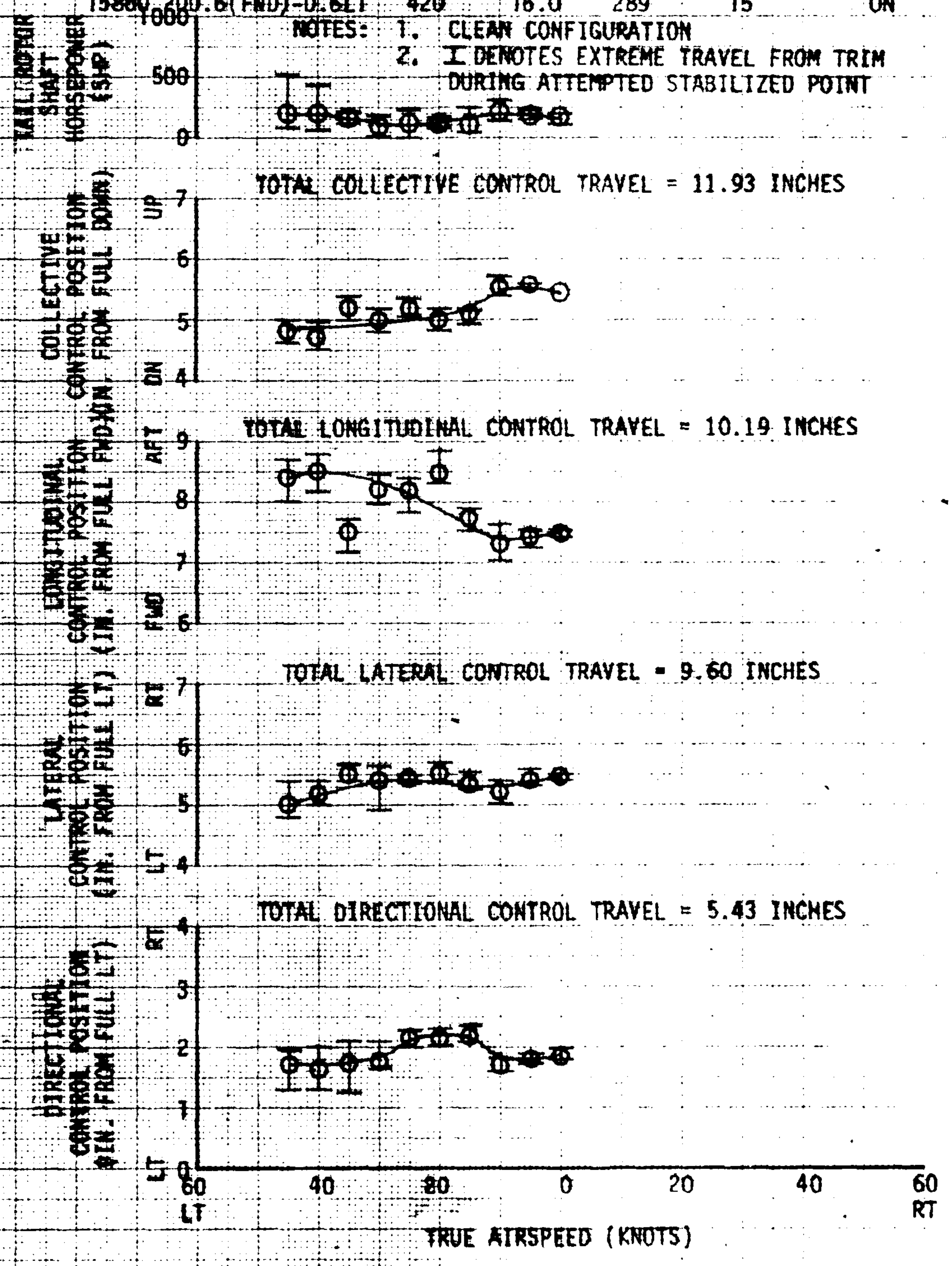


FIGURE 40

SIDEWARD FLIGHT

YAH-64 USA S/N 74-22249

CRITICAL AZIMUTH 250 DEGREES

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (^{0}C)	AVG ROTOR SPEED (RPM)	WHEEL HEIGHT	ASE CONDITION
14600	200.2 (FWD)	-0.6 LT	260	13.0	289	15	ON

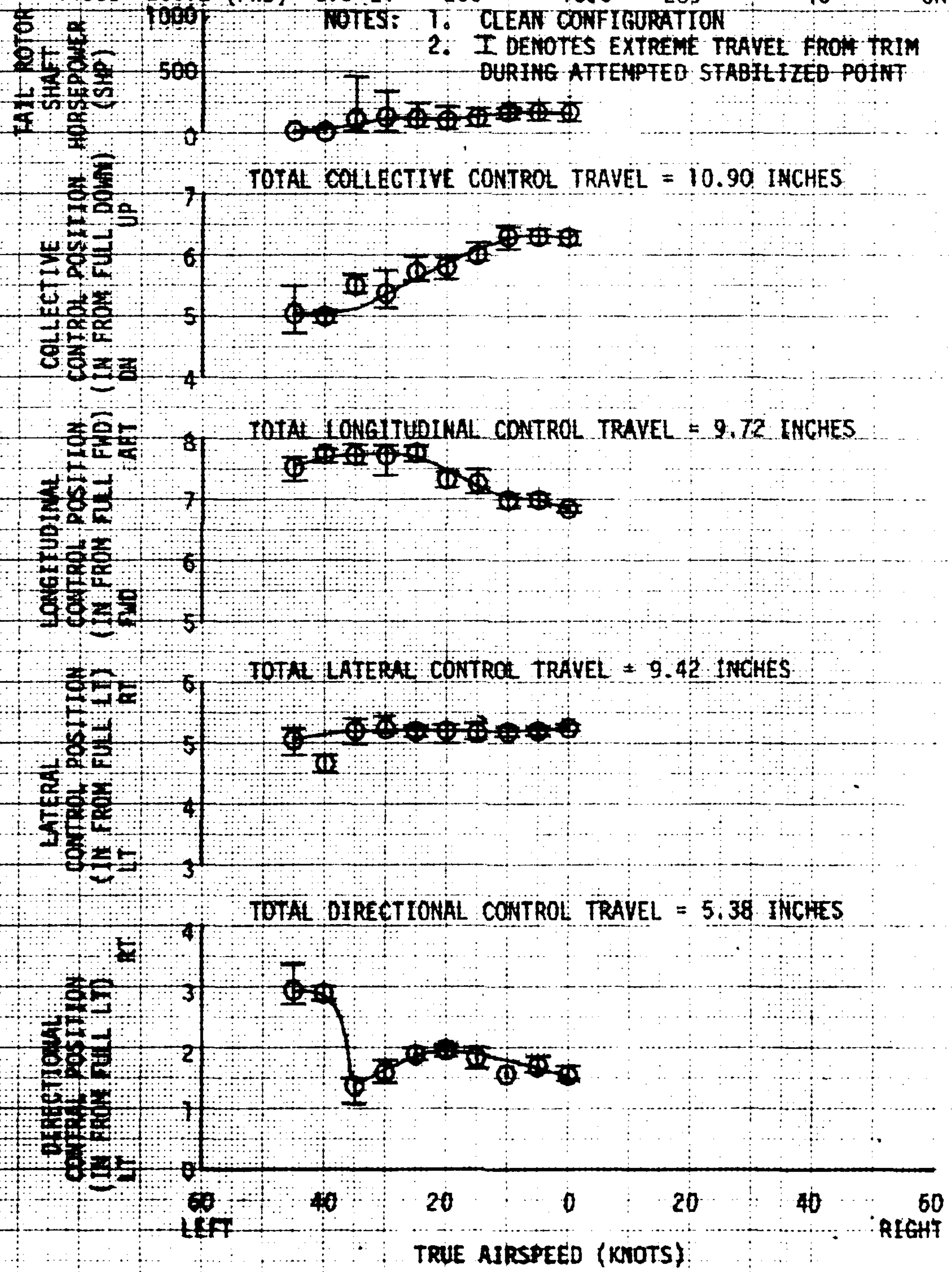
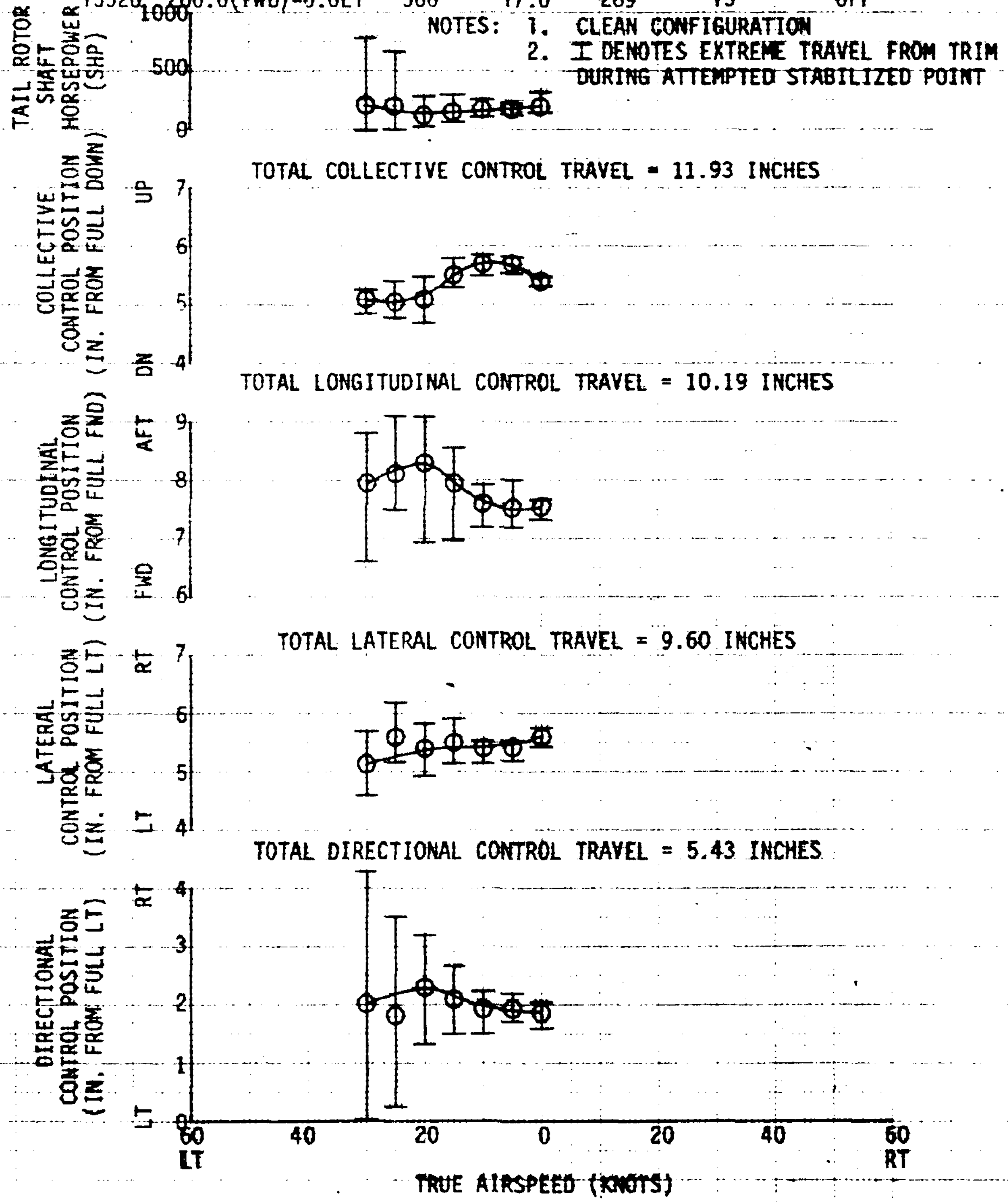


FIGURE 41
SIDEWARD FLIGHT
YAH-64 USA S/N 74-22248
CRITICAL AZIMUTH 250 DEGREES

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	WHEEL HEIGHT (FT)	ASE CONDITION
15520	200.6(FWD)	0.6LT	560	17.0	289	15	OFF



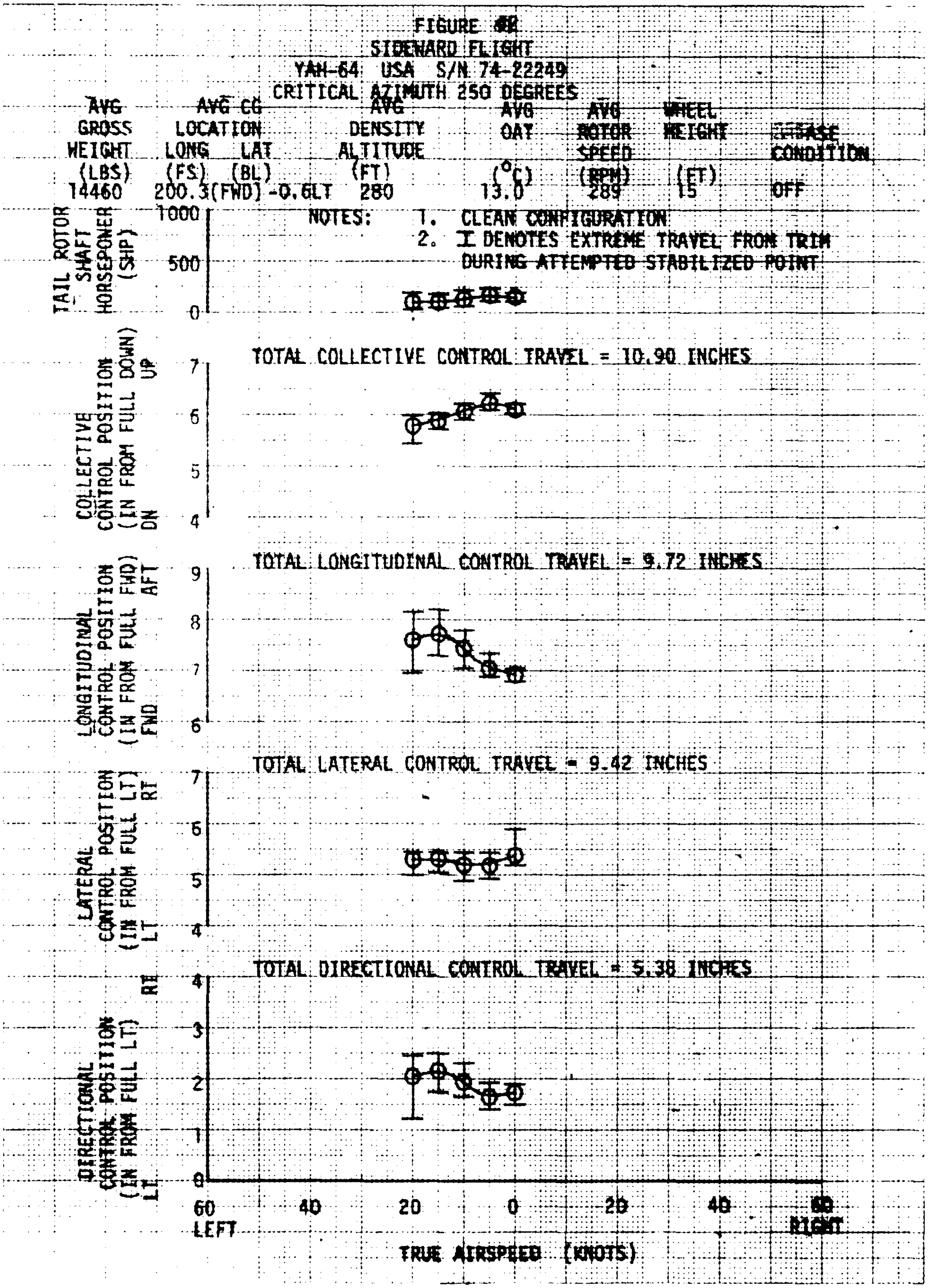


FIGURE 42
SIDEWARD FLIGHT
YAH-64 USA S/N 74-22249
CRITICAL AZIMUTH 250 DEGREES
AVG GROSS WEIGHT (LBS) 14460
AVG CG LOCATION LONG (FS) 200.3(FWD) LAT (BL) -0.6LT
AVG DENSITY ALTITUDE (FT) 280
AVG OAT (°C) 13.0
AVG ROTOR SPEED (RPM) 289
WHEEL HEIGHT (FT) 15
CONDITION OFF
NOTES: 1. CLEAN CONFIGURATION
2. I DENOTES EXTREME TRAVEL FROM TRIM DURING ATTEMPTED STABILIZED POINT
TAIL ROTOR SHAFT HORSEPOWER (SHP)
TOTAL COLLECTIVE CONTROL TRAVEL = 10.90 INCHES
COLLECTIVE CONTROL POSITION (IN FROM FULL DOWN)
UP
DN
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.72 INCHES
LONGITUDINAL CONTROL POSITION (IN FROM FULL FWD)
AFT
FWD
TOTAL LATERAL CONTROL TRAVEL = 9.42 INCHES
LATERAL CONTROL POSITION (IN FROM FULL LT)
RT
LT
TOTAL DIRECTIONAL CONTROL TRAVEL = 5.38 INCHES
DIRECTIONAL CONTROL POSITION (IN FROM FULL LT)
RT
LT
60 LEFT
40
20
0
20
40
60 RIGHT
TRUE AIRSPEED (KNOTS)

FIGURE 42
LOW SPEED FORWARD AND REARWARD FLIGHT
YAH-64 USA S/N 74-22249

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (^{0}C)	AVG ROTOR SPEED (RPM)	WHEEL HEIGHT (FT)	ASE [illegible] CONDITION
15100	200.0(FWD)	-0.6LT	120	11.5	289	15	ON

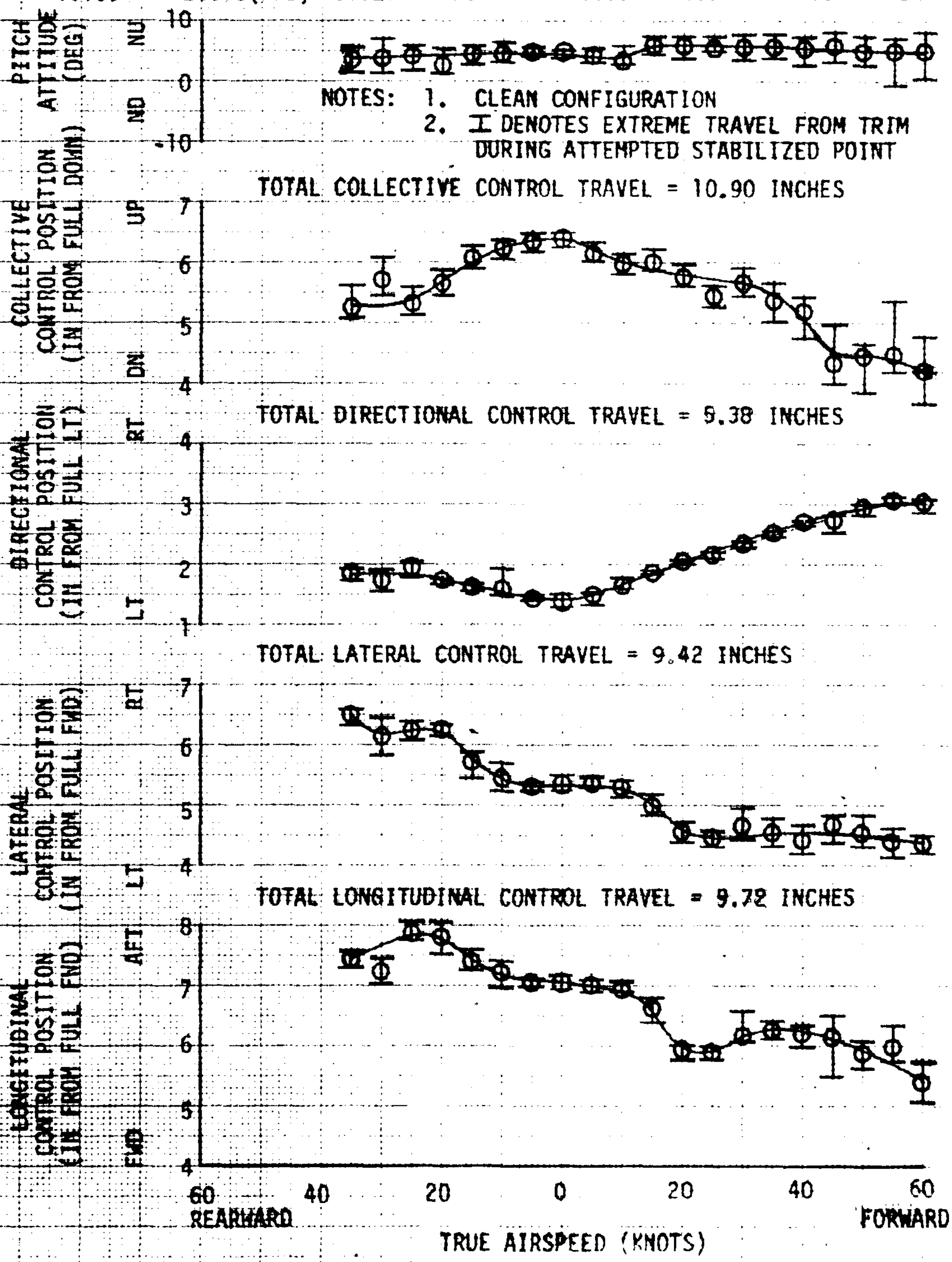


FIGURE 44

LOW SPEED FORWARD AND REARWARD FLIGHT

YAH-64 USA S/N 74-22249

AVG GROSS WEIGHT (LB)	AV CG LOCATION LONG (FS)	AV CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (^{0}C)	AVG ROTOR SPEED (RPM)	WHEEL HEIGHT	ASE CONDITION
14760	199.3(FWD)	-0.6 LT	220	12.5	289	15	OFF

NOTES:
1. CLEAN CONFIGURATION
2. I DENOTES EXTREME TRAVEL FROM TRIM DURING ATTEMPTED STABILIZED POINT

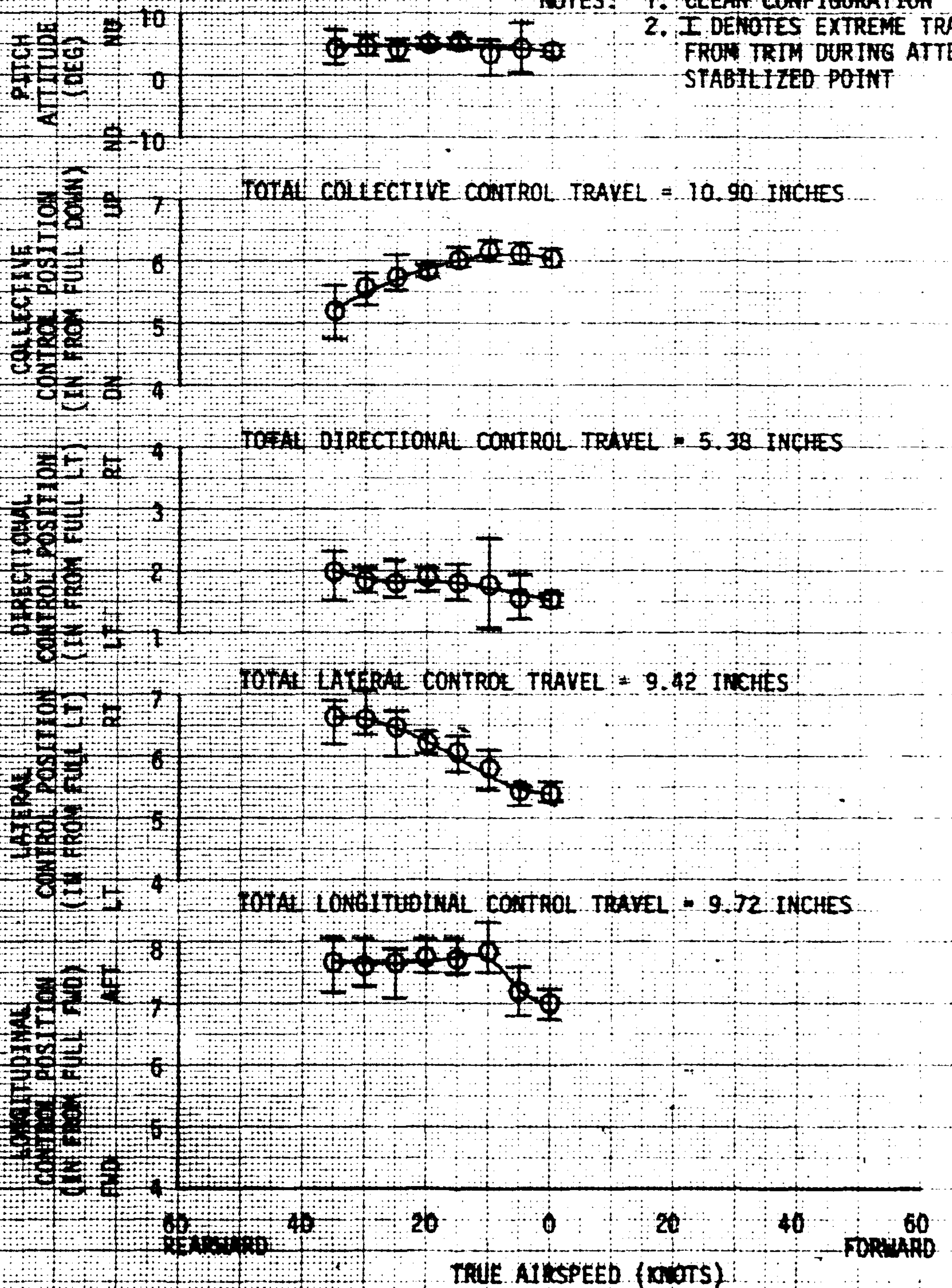


FIGURE 45
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
PILOT SEAT VERTICAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG LAT (FS) (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14620	200.3(FWD) -0.6LT	3860	16.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

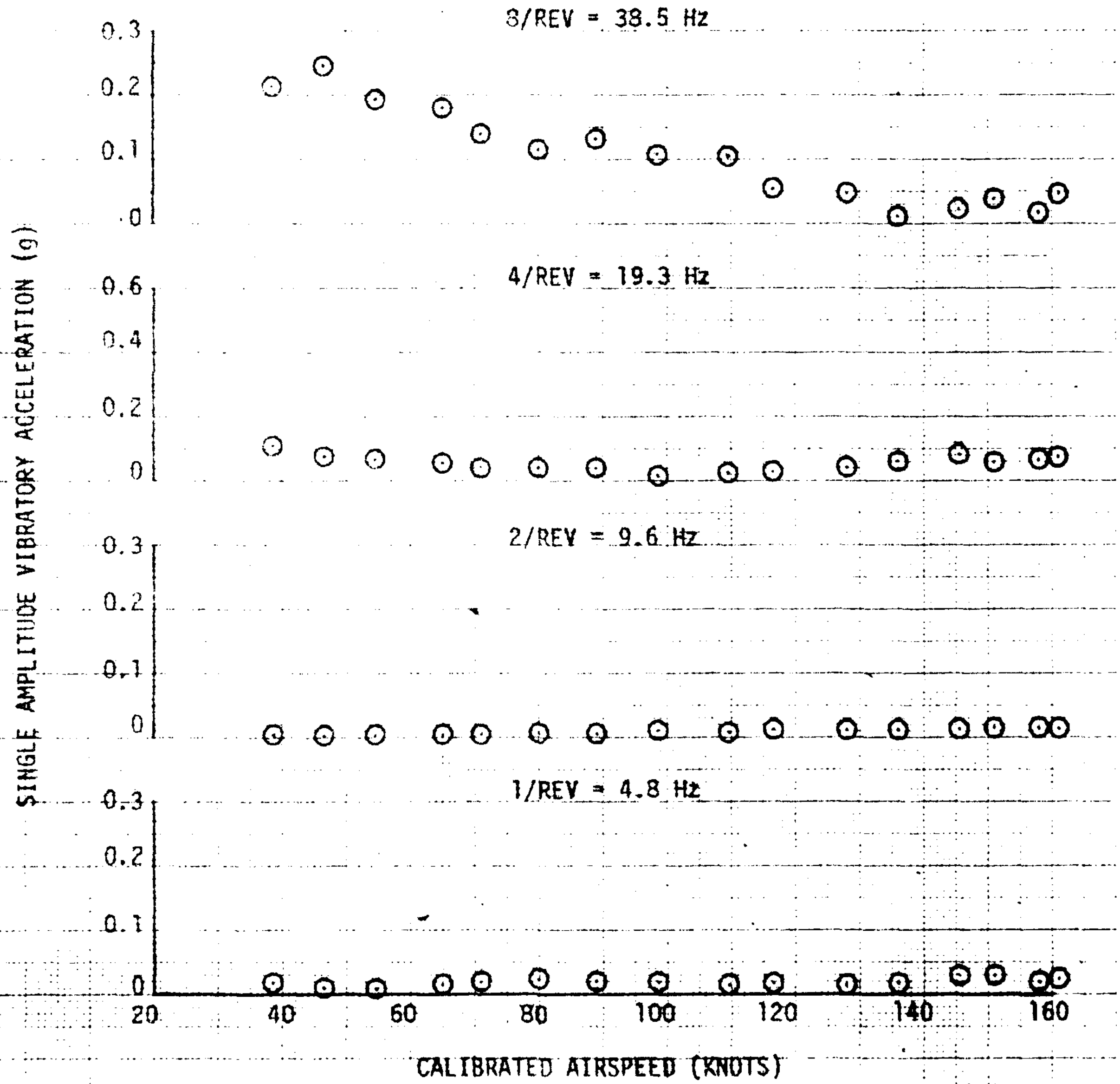


FIGURE 46

VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
PILOT SEAT LATERAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14620	200.3(FWD)	-0.6LT	3860	16.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

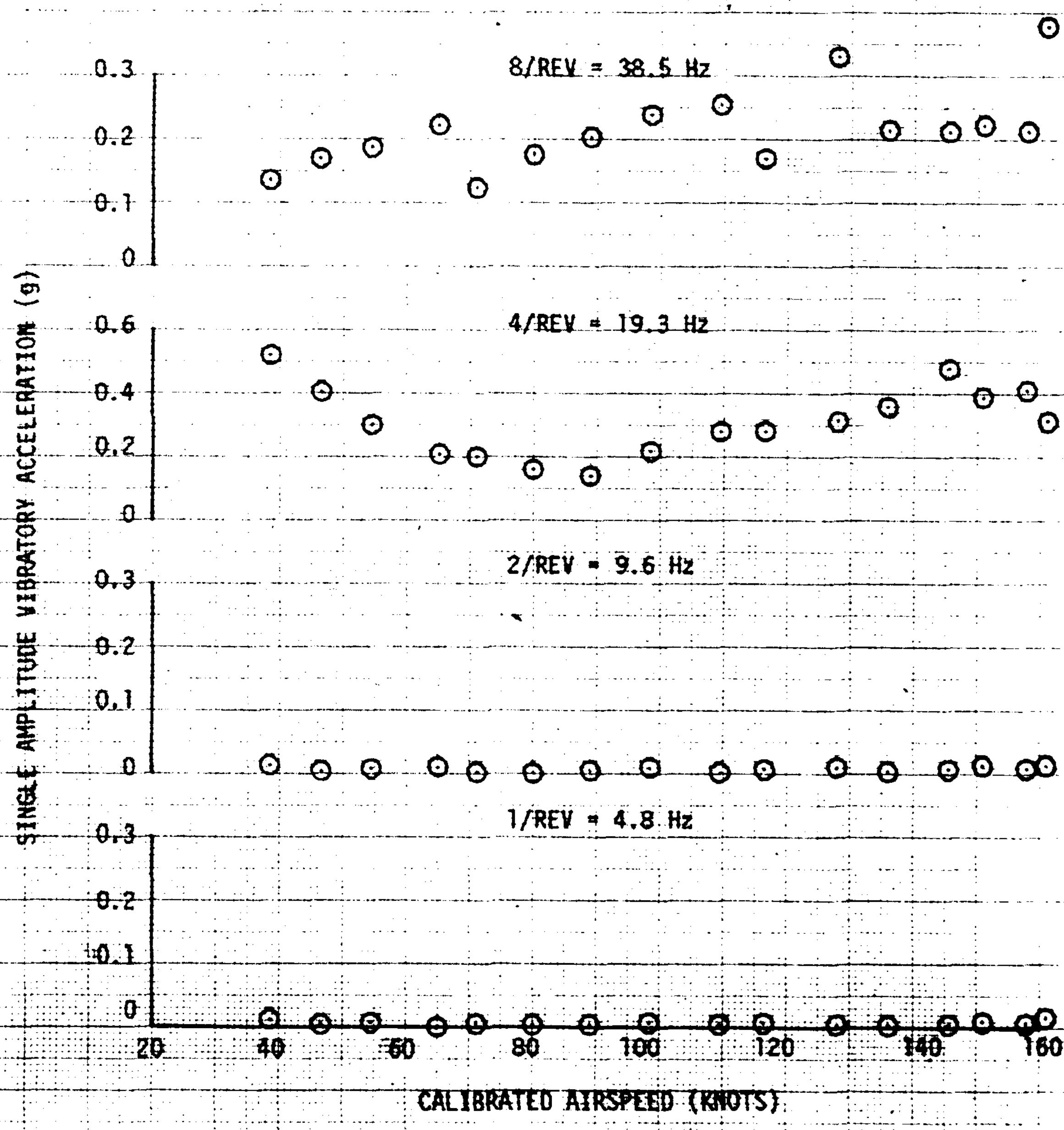


FIGURE 47
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
PILOT SEAT LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14620	200.3(FWD)	-0.6LT	3860	16.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

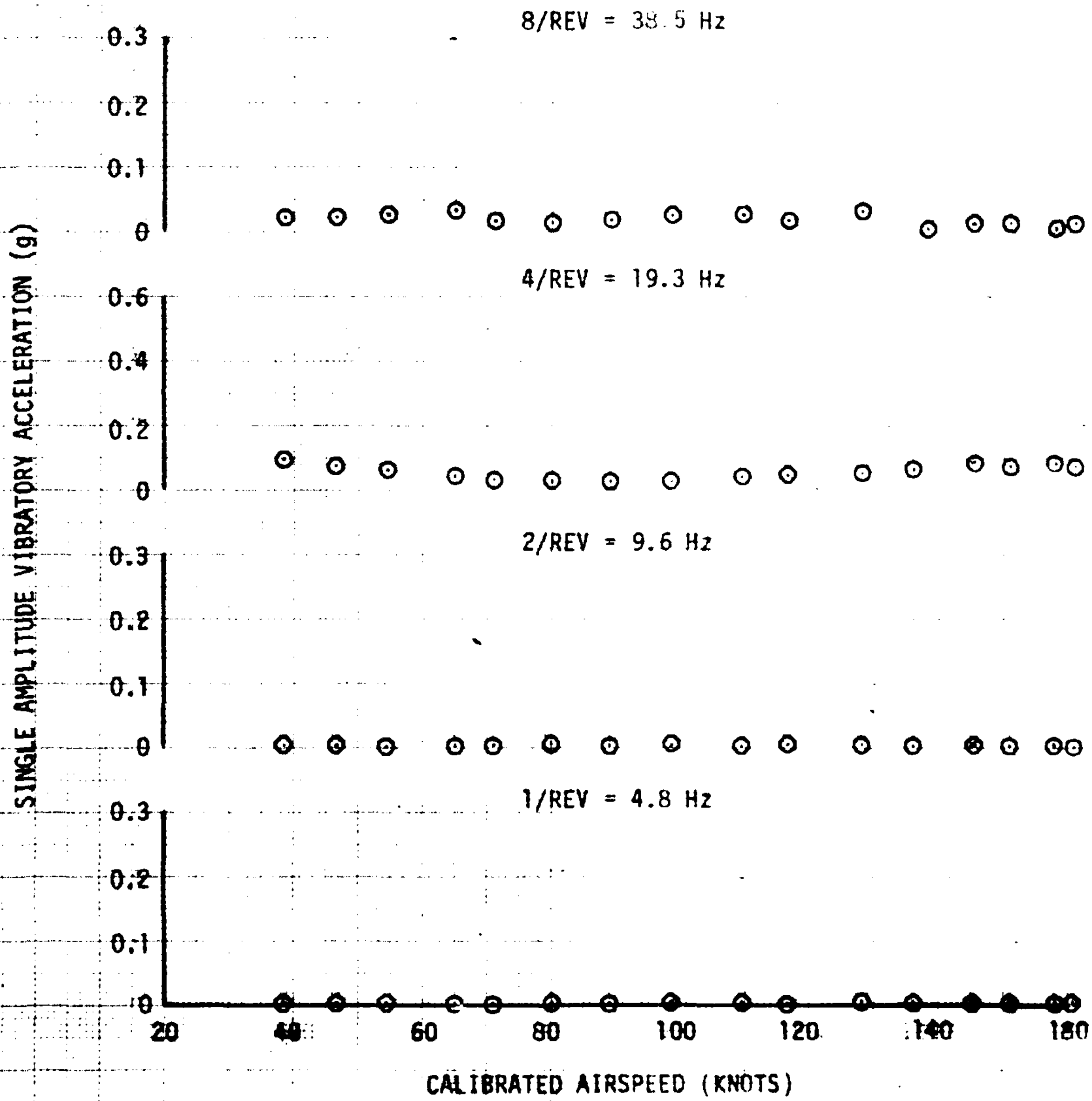


FIGURE 48
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
COPILOT SEAT VERTICAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (LB)	AVG DENSITY ALTITUDE (FT)	AV OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14620	200.3(FWD)	-0.6LT	3860	16.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

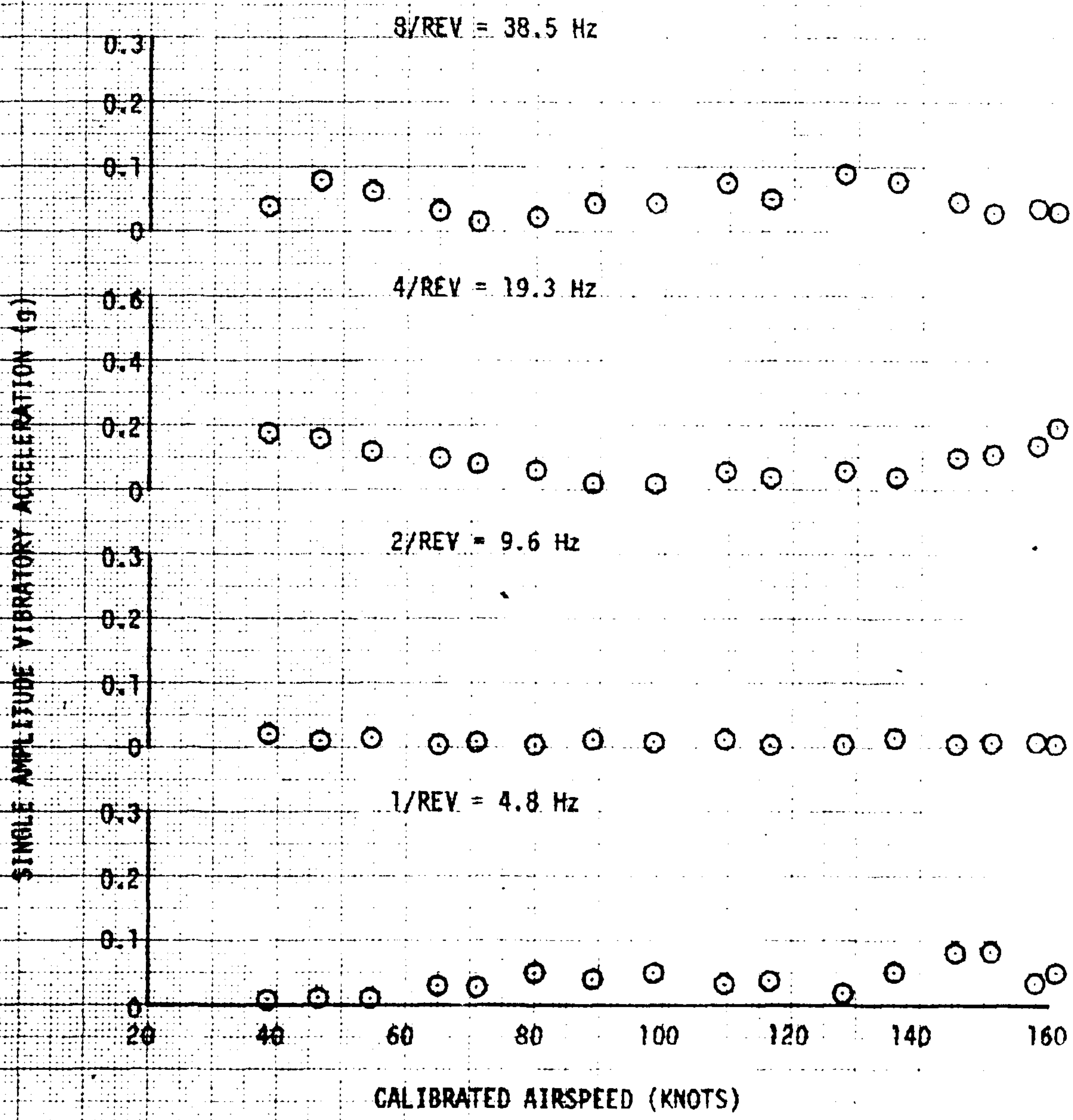


FIGURE 49

VIBRATION CHARACTERISTICS

YAH-64 USA S/N 74-22248

COPILOT SEAT LATERAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT ($^{\circ}$C)	AV ROTOR SPEED (RPM)	FLIGHT CONDITION
14620	200.3(FWD)	-0.6LT	3860	16.0	289	LVL

NOTE: 8 HELLFIRE CONFIGURATION

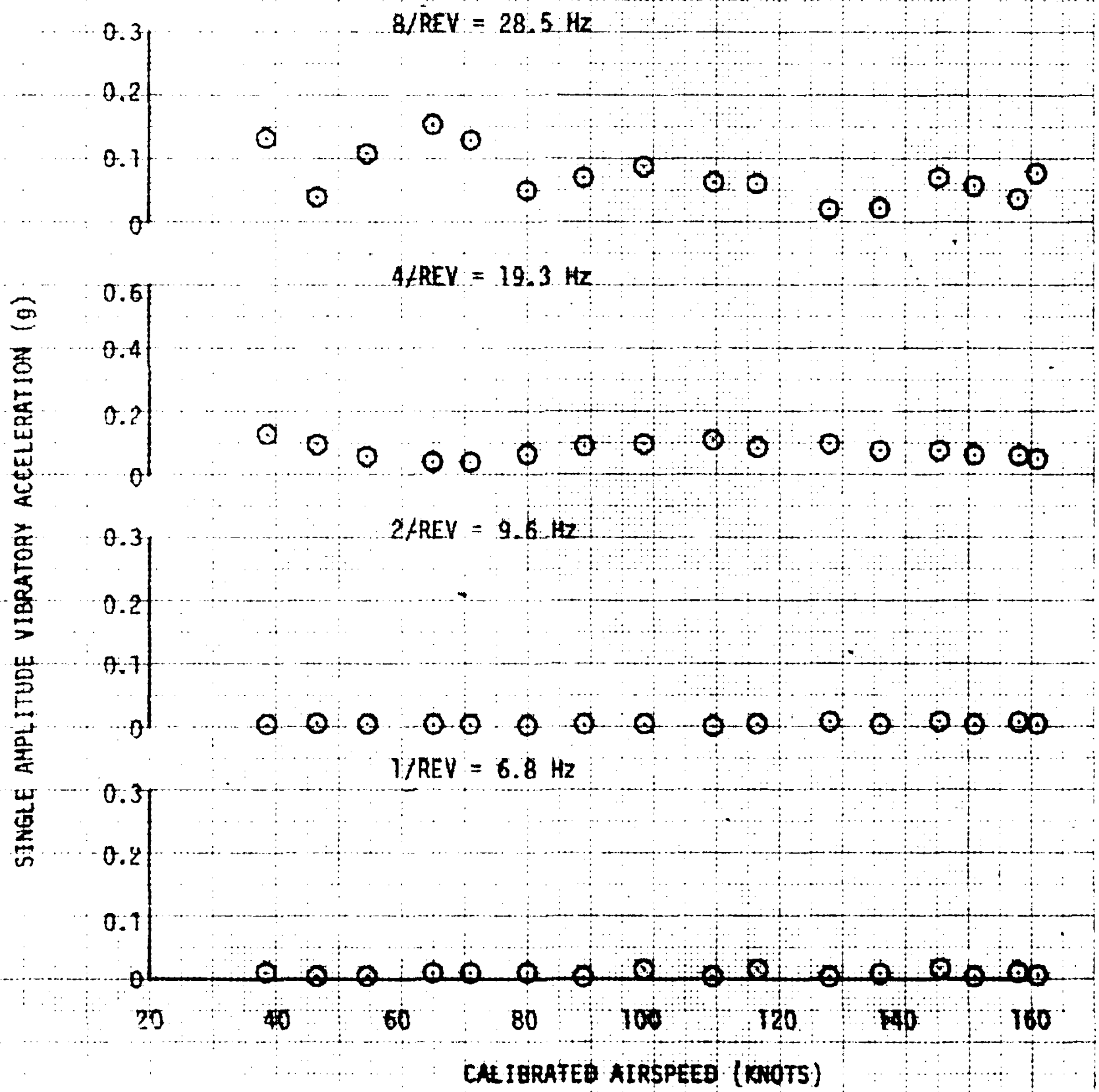


FIGURE 50
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
COPILOT SEAT LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14620	200.3(FWD)	-0.6LT	3860	16.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

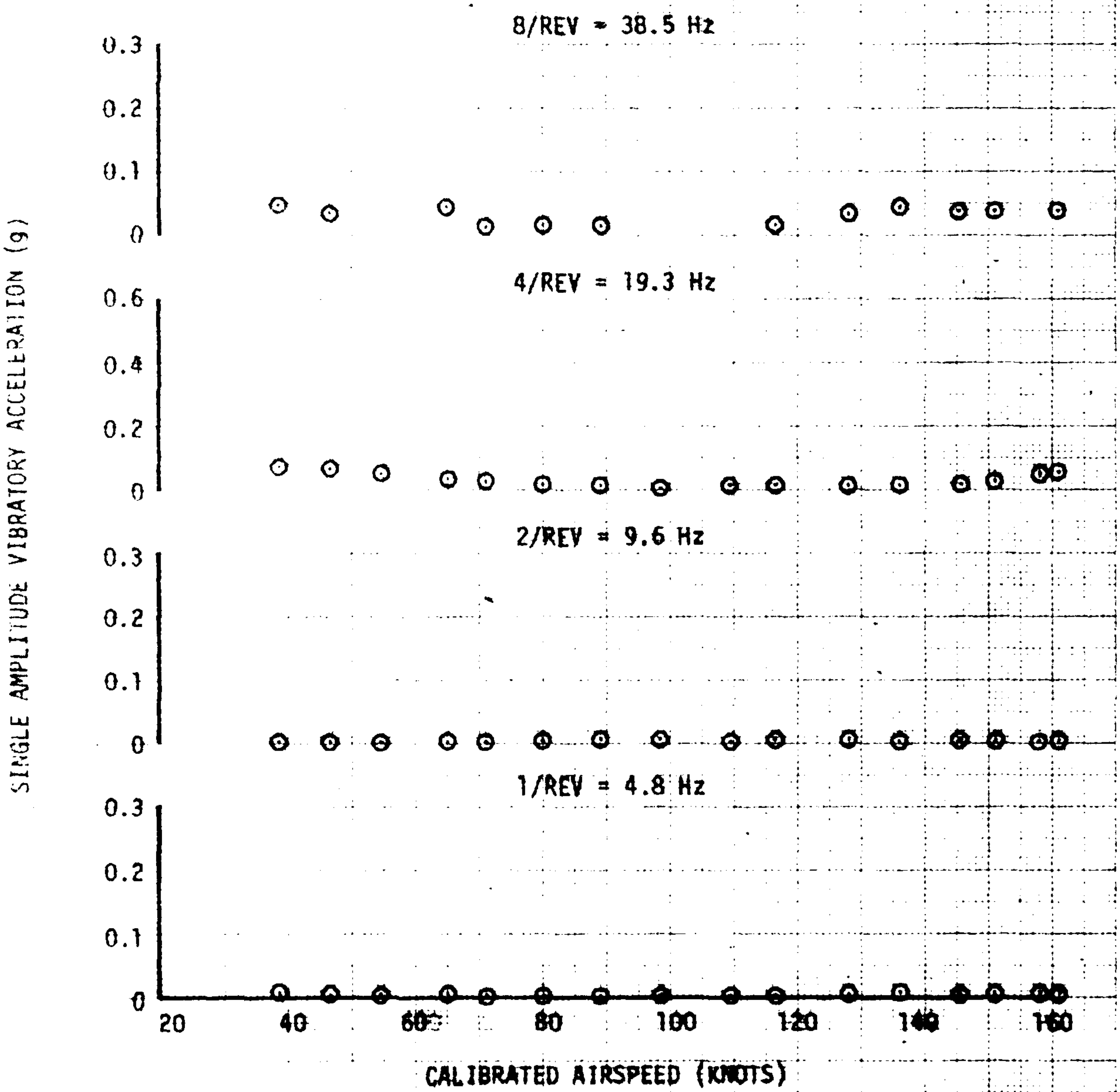


FIGURE 5C
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
AIRCRAFT CG VERTICAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14620	200.3(FWD)	-0.6LT	3860	16.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

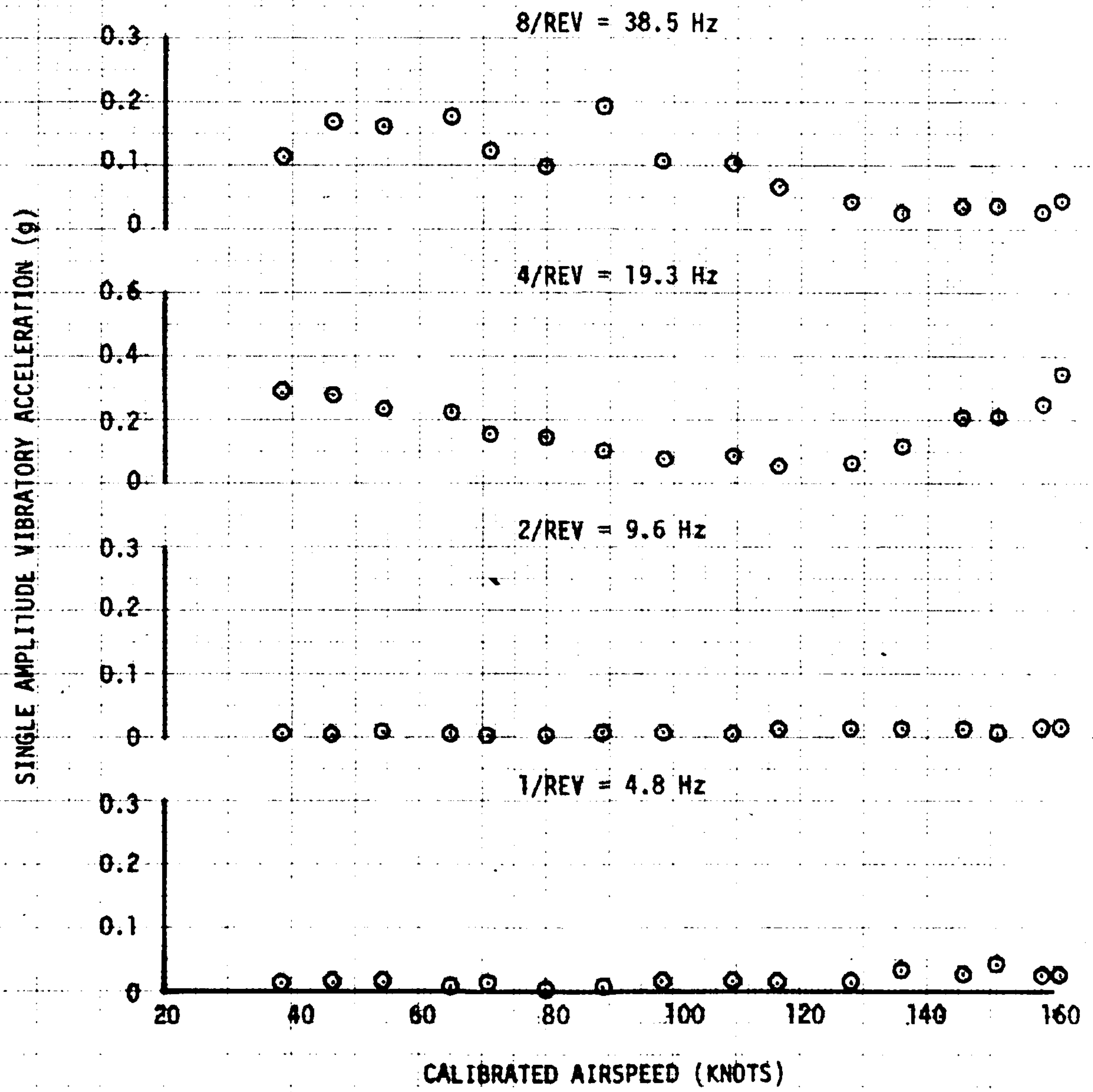


FIGURE 52
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
AIRCRAFT CG LATERAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14620	200.3(FWD)	-0.6LT	3860	16.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

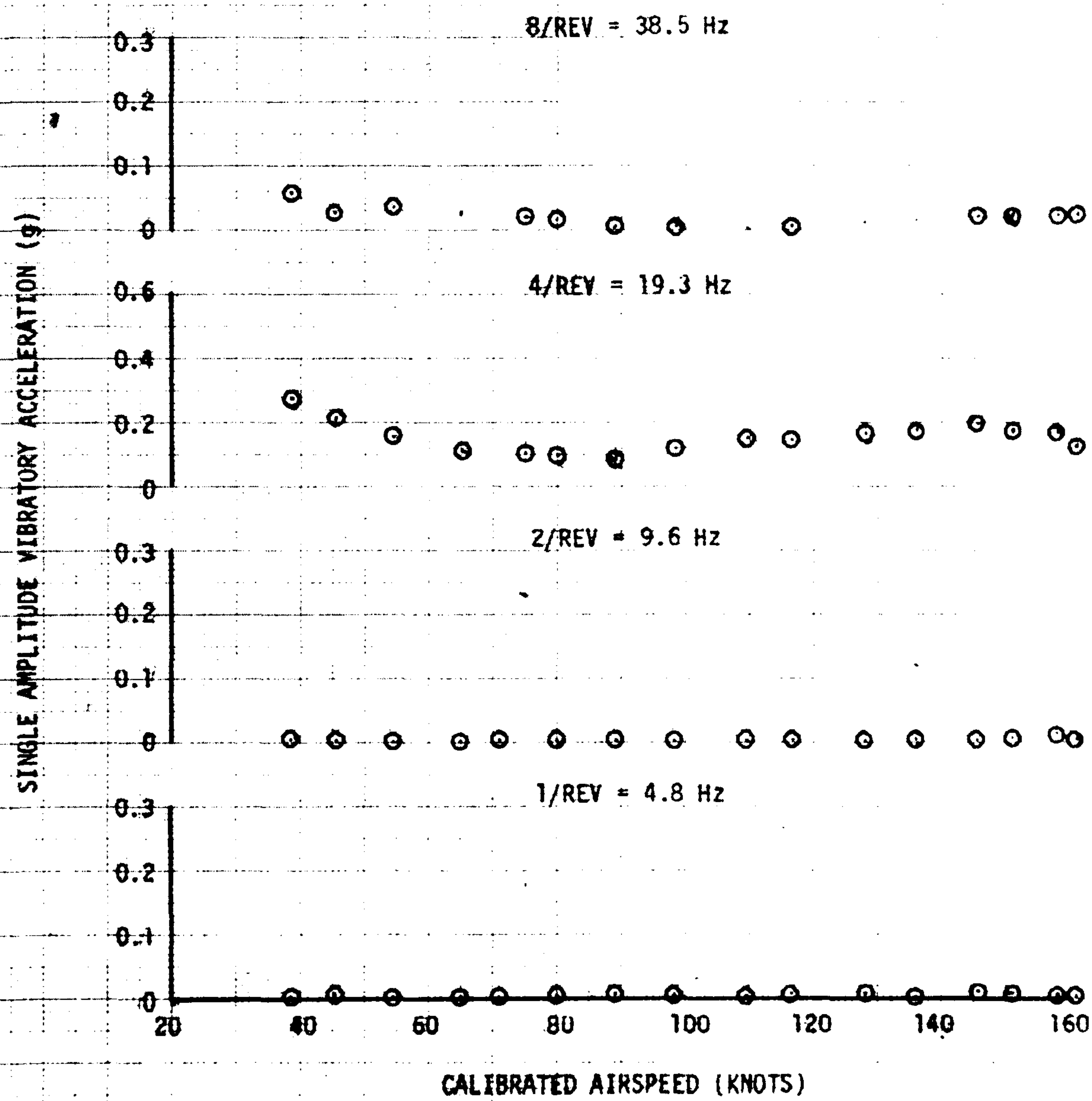


FIGURE 53
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
AIRCRAFT CG LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14620	200.3(FWD)	-0.6LT	3860	16.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

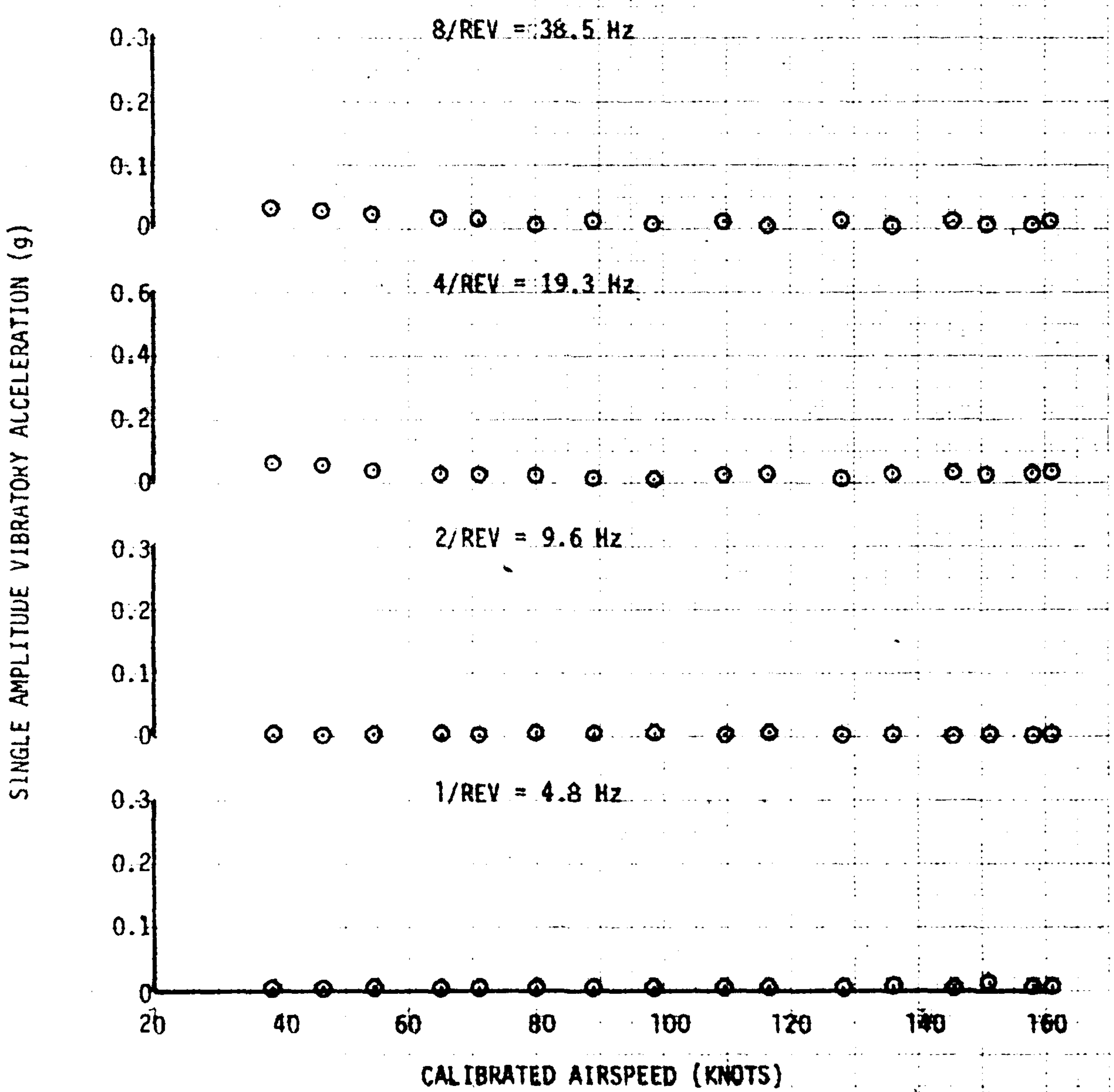


FIGURE 54
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
PILOT SEAT VERTICAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED	FLIGHT CONDITION
14940	199.4(FWD)	-0.6LT	2560	15.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

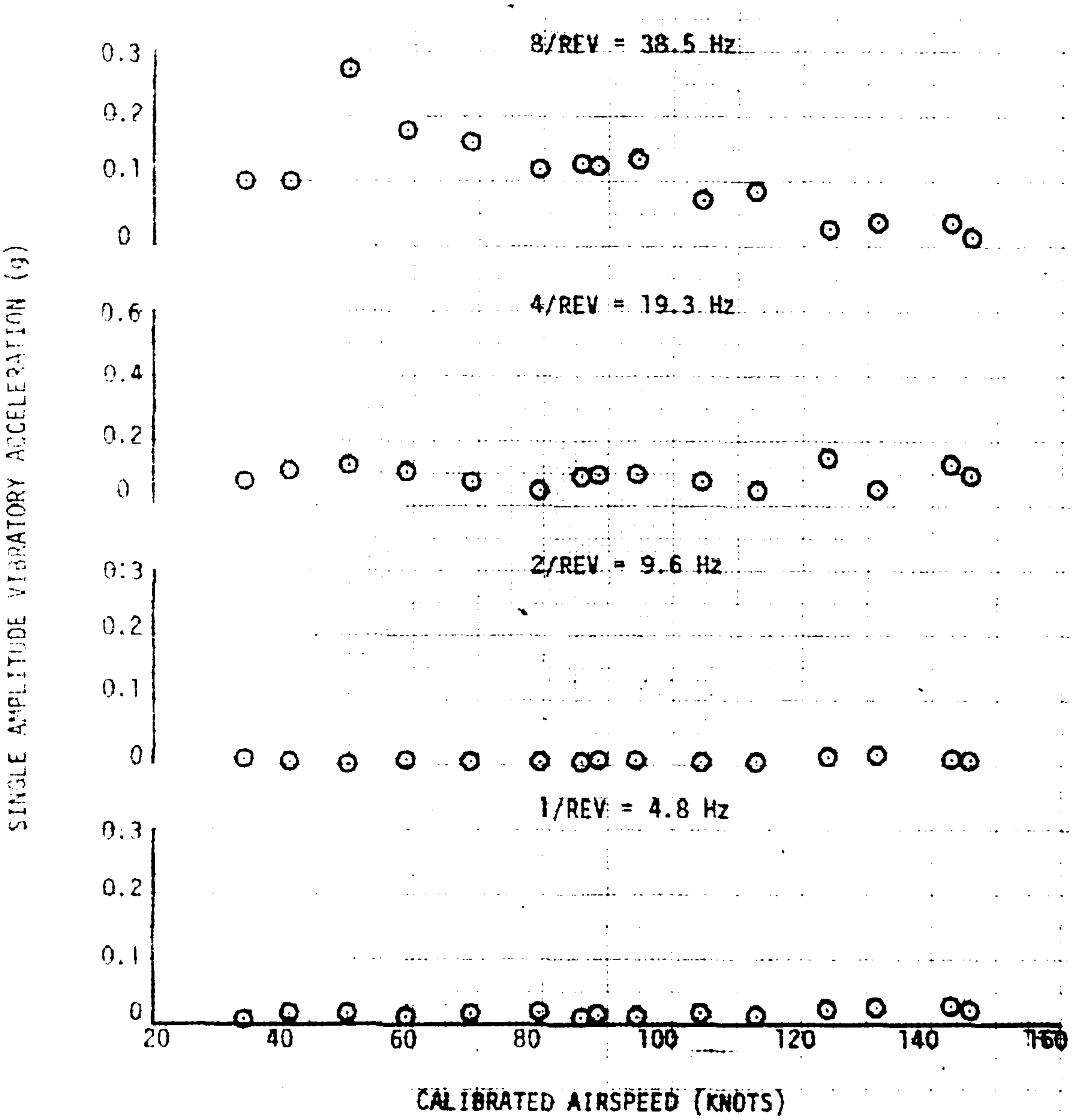


FIGURE 65
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
PILOT SEAT LATERAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14940	199.4(FWD)	-0.6LT	2560	15	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

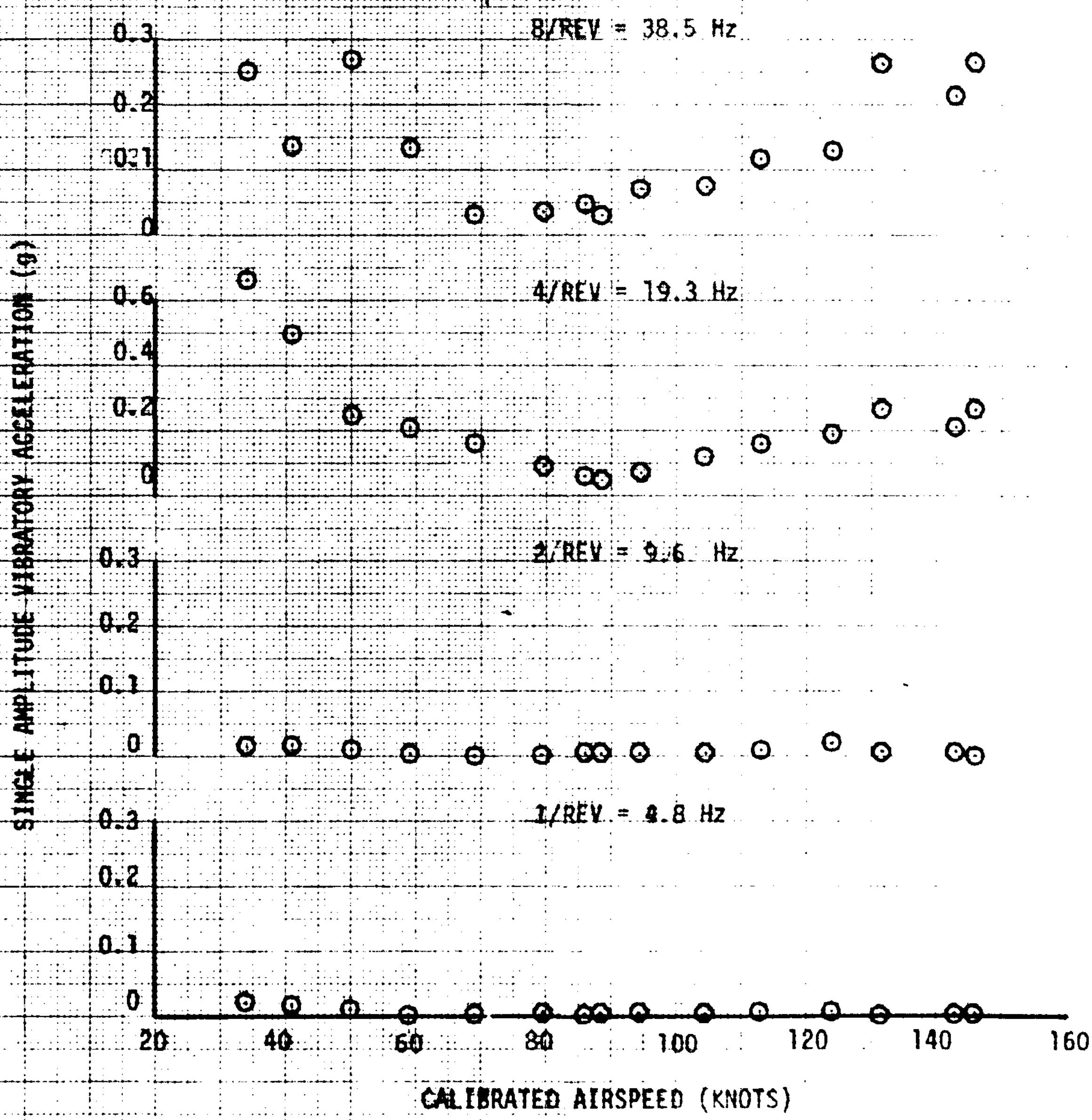


FIGURE 56
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
PILOT SEAT LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14940	199.4(FWD)	-0.6LT	2560	15.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

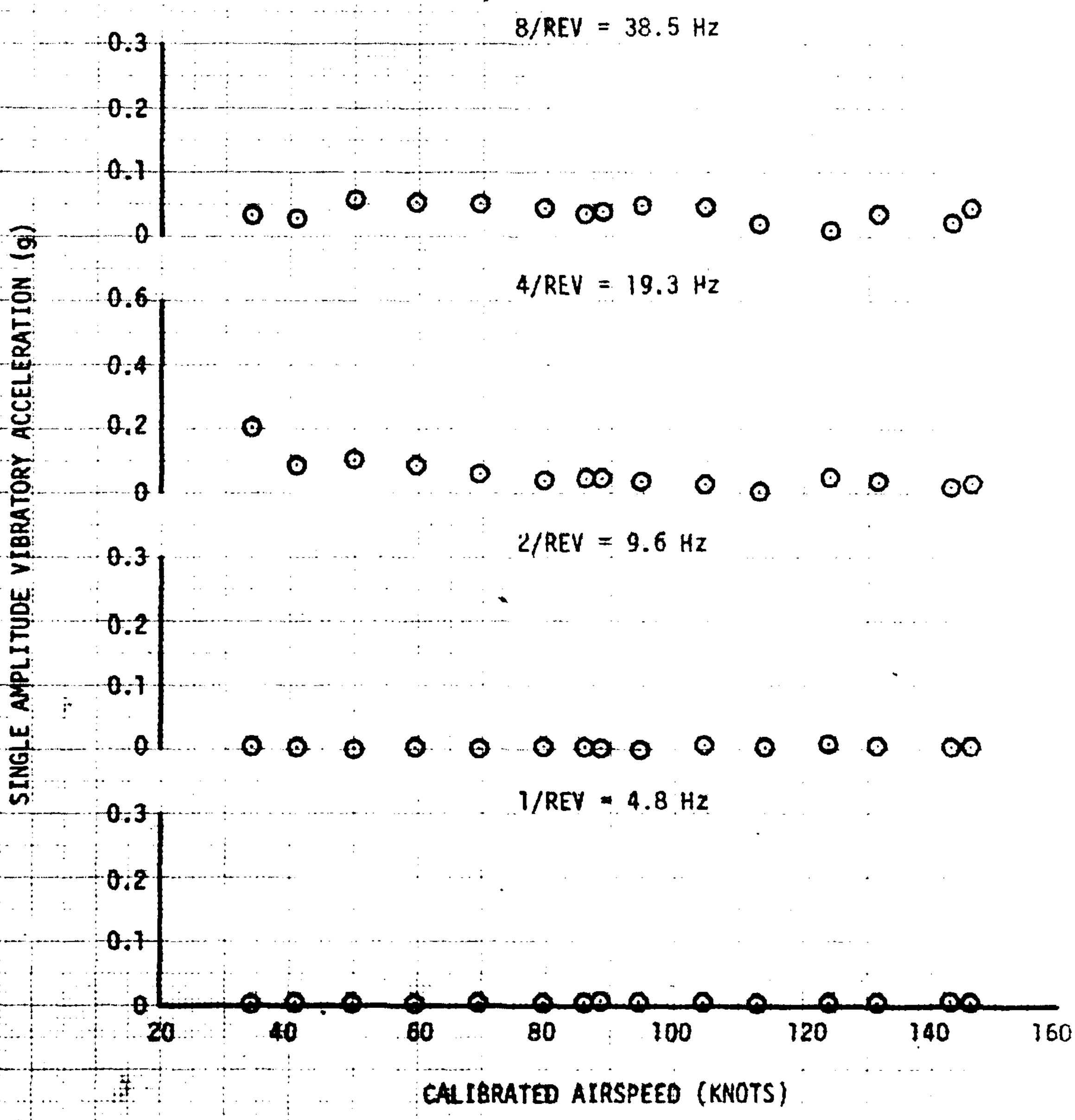


FIGURE 57

VIBRATION CHARACTERISTICS

YAH-64 USA S/N 74-22249

COPILOT SEAT VERTICAL

AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14940	199.4(FWD)	-0.6LT	2560	15.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

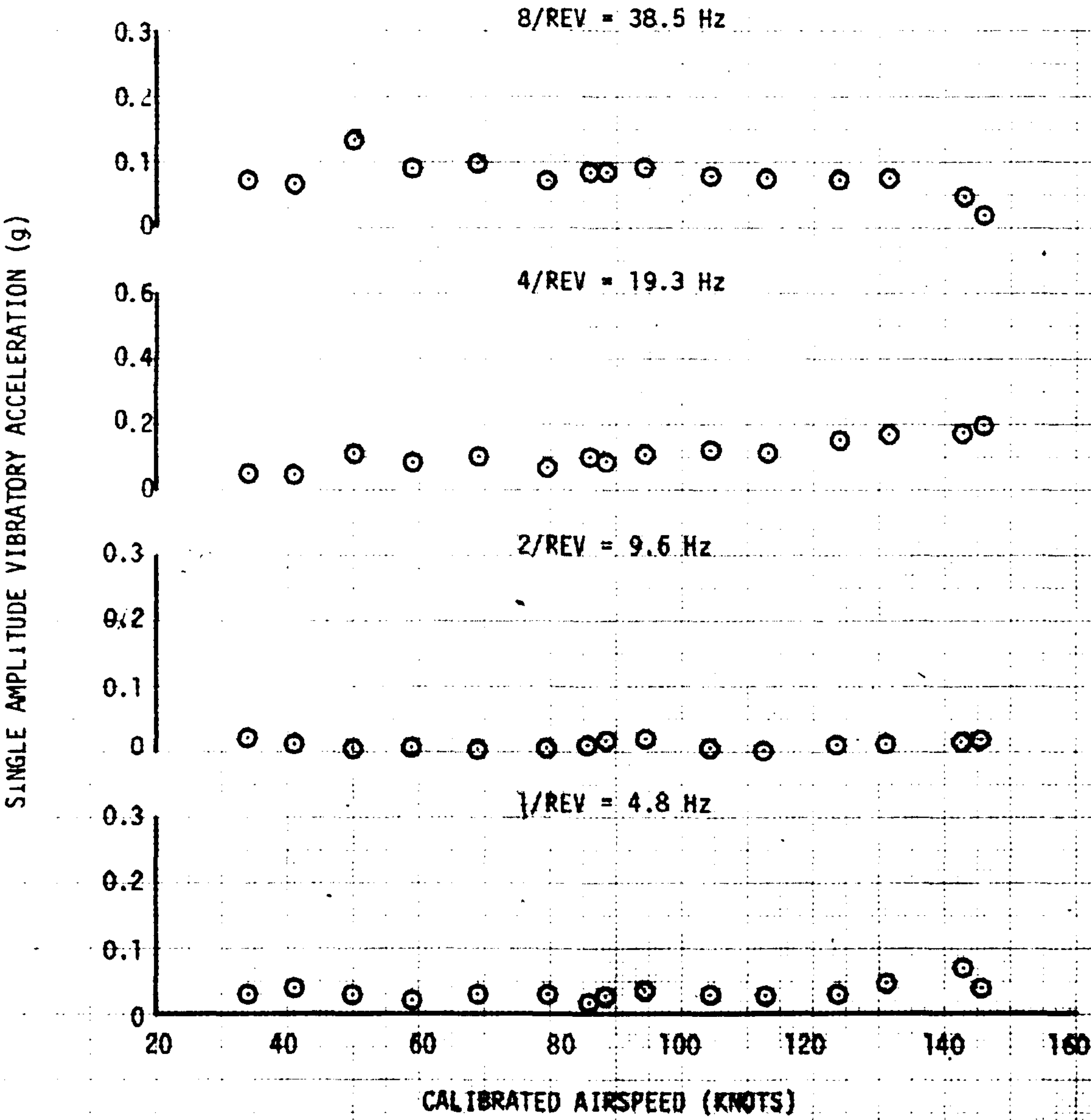


FIGURE 58
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
COPILOT SEAT LATERAL

AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14940	199.4(FWD)	-0.6LT	2560	15.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

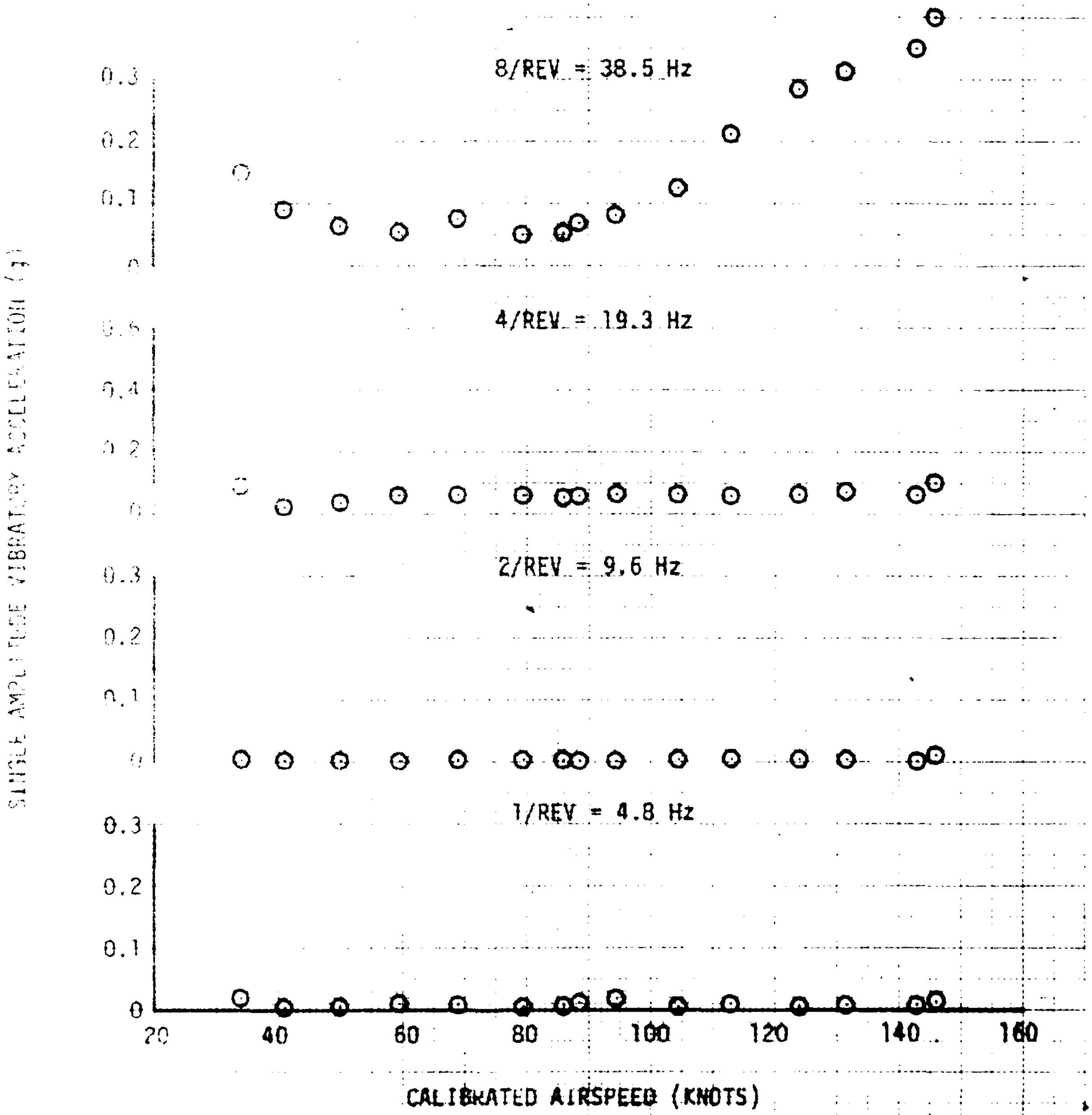


FIGURE 59
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
COPILOT SEAT LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14940	199.4(FWD)	-0.6LT	2560	15.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

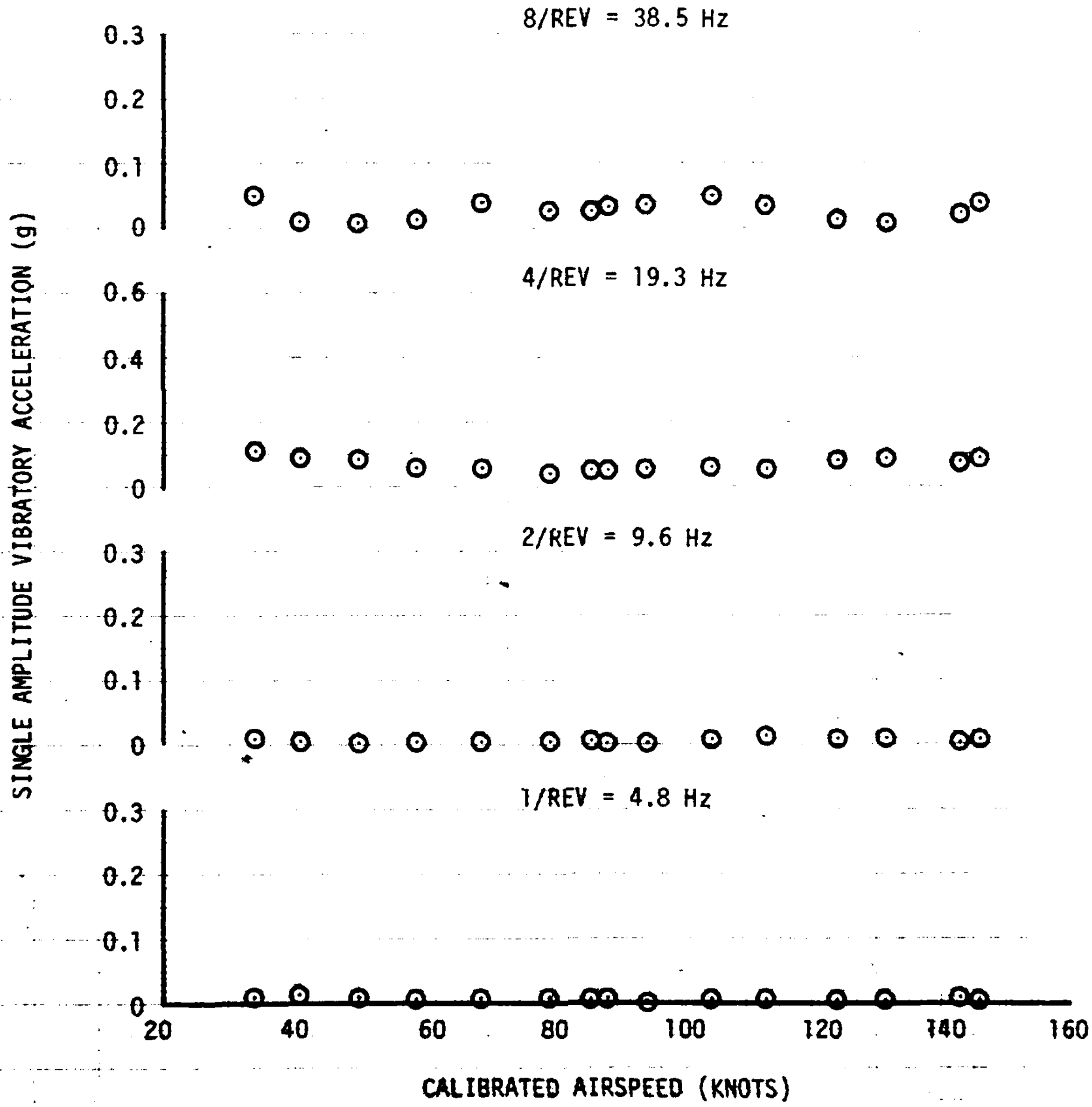


FIGURE 60
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
AIRCRAFT CG VERTICAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14940	199.4(FWD)	-0.6LT	2560	15.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

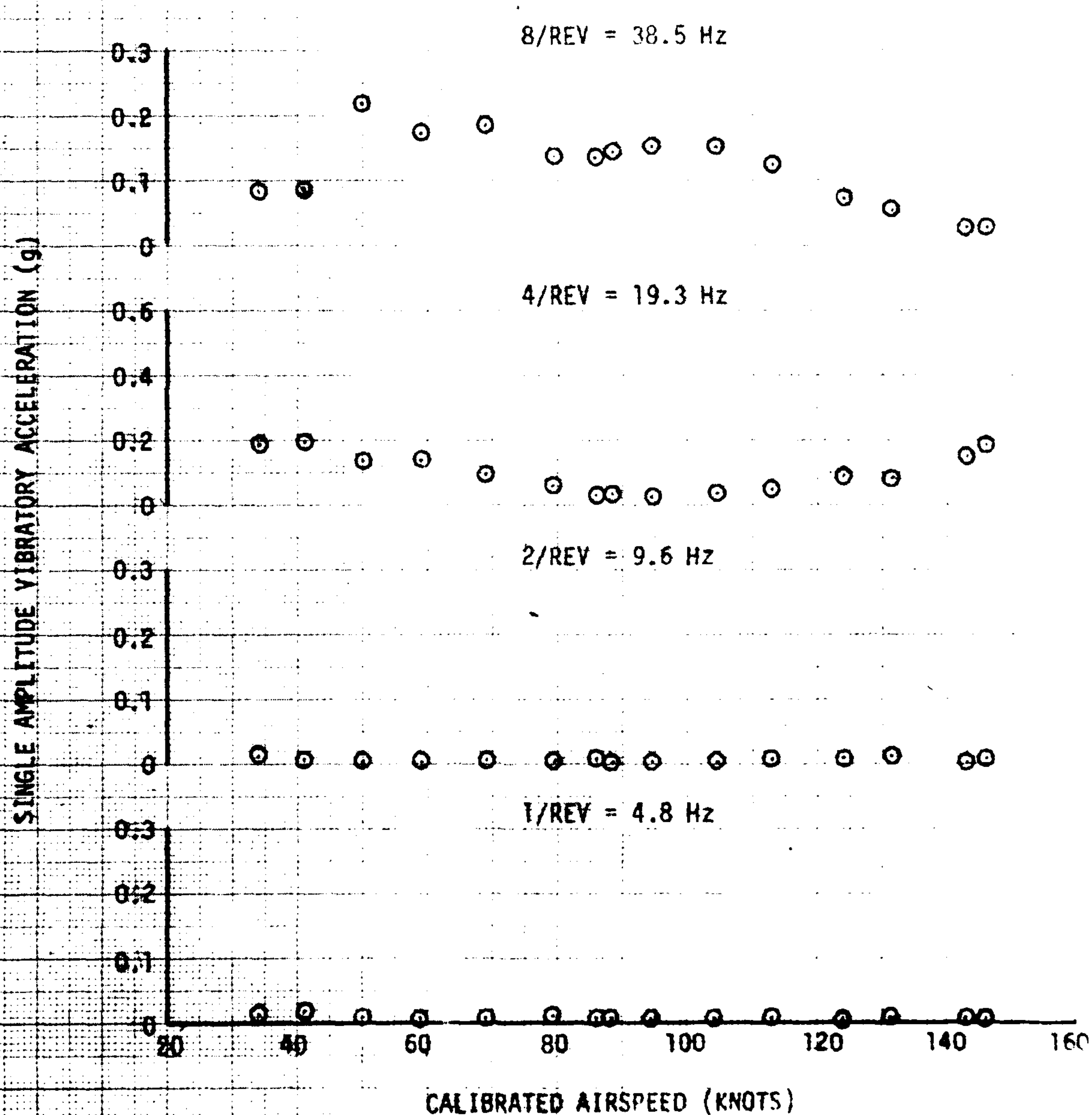


FIGURE 61
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
AIRCRAFT CG LATERAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14940	199.4(FWD)	-0.6LT	2560	15.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

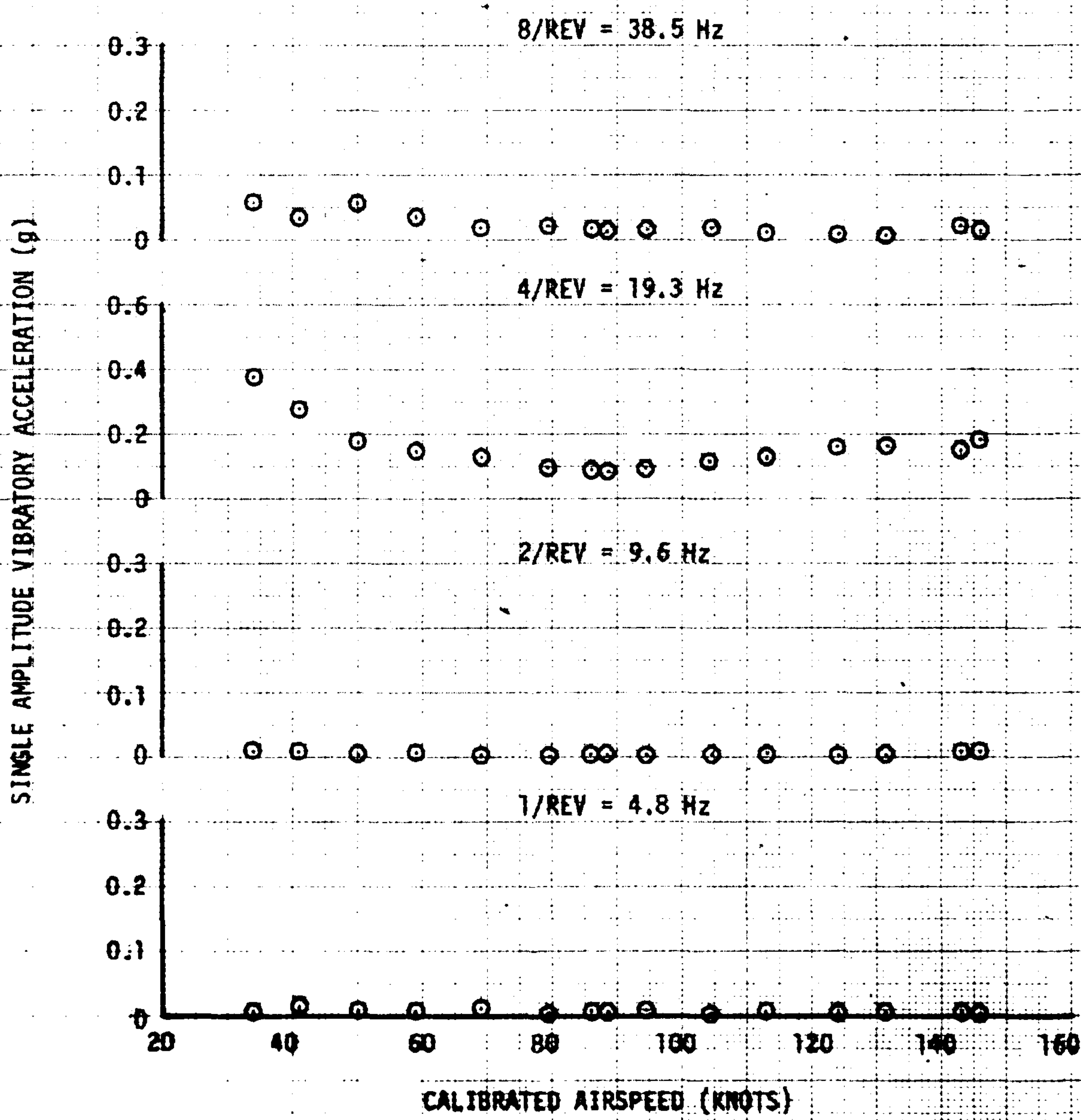


FIGURE 62
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
AIRCRAFT CG LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
14940	199.4(FWD)	-0.6LT	2560	15.0	289	LVL FLT

NOTE: 8 HELLFIRE CONFIGURATION

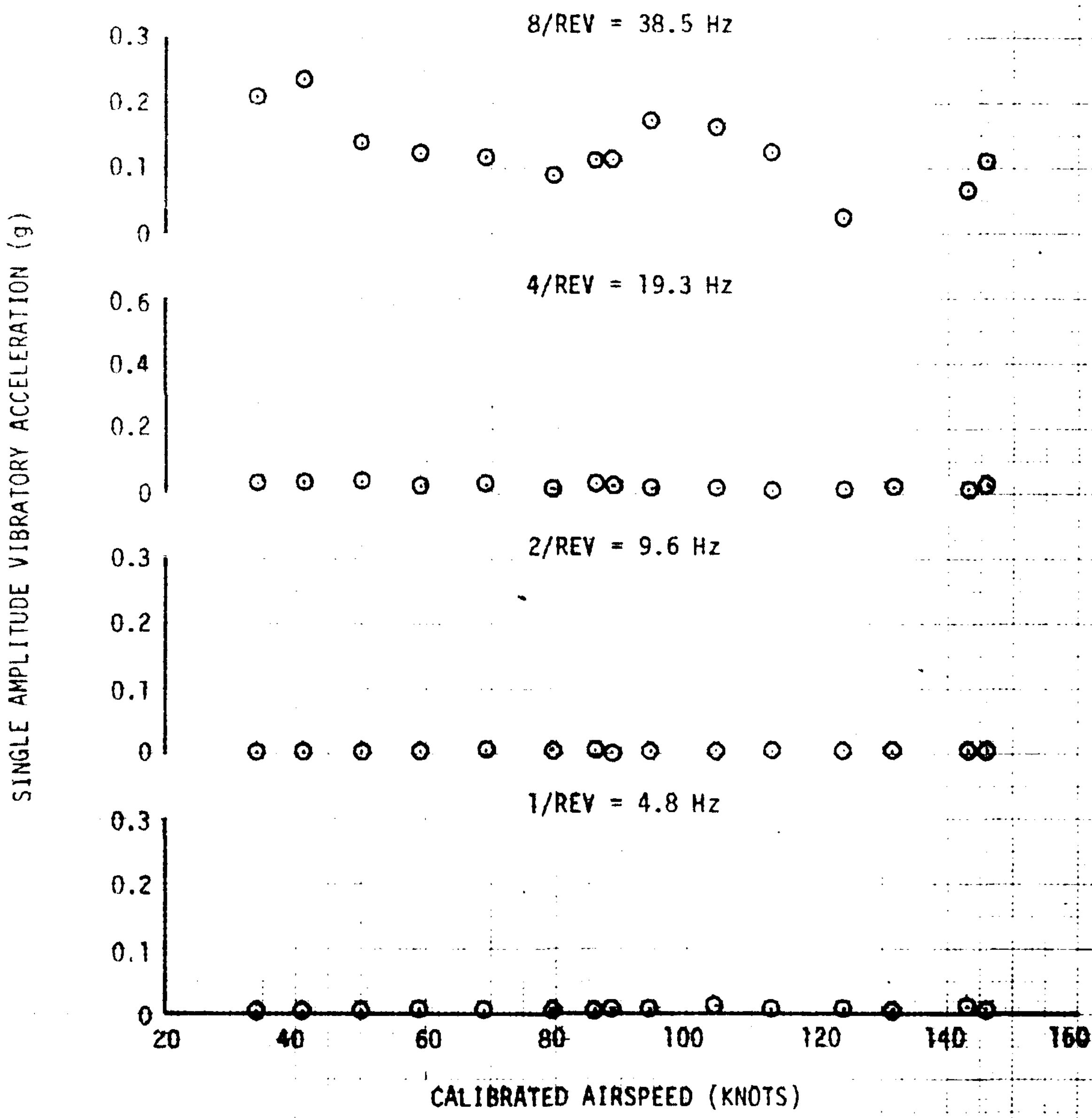


FIGURE 63
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
PILOT SEAT VERTICAL

SYM	AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
⊙	14060	206.6(AFT)	-0.5LT	5880	16.0	289	IRP CLIMB
⊡	14200	206.6(AFT)	-0.5LT	5260	16.5	289	MIN POWER

NOTE: CLEAN CONFIGURATION

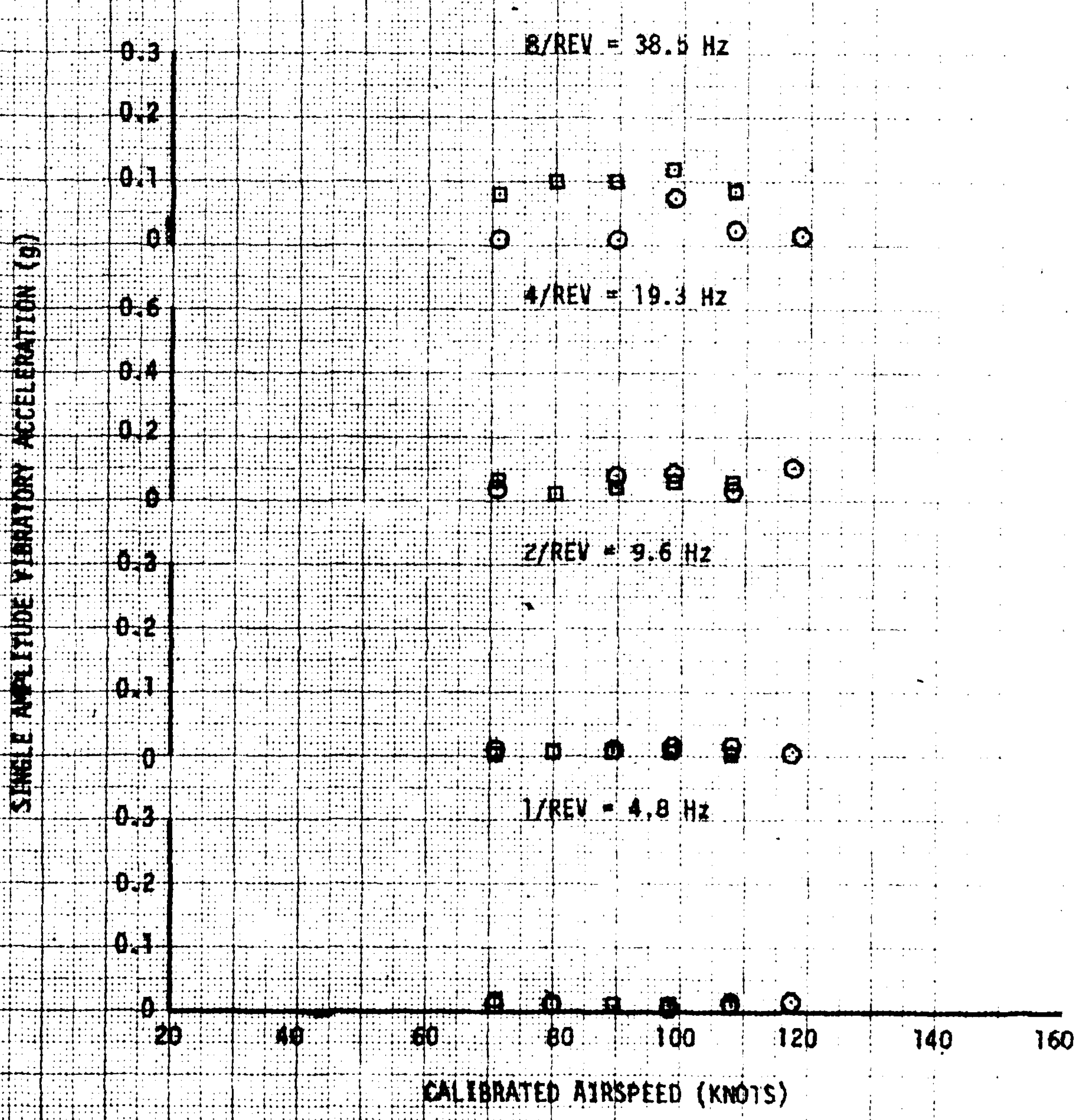


FIGURE 64
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
PILOT SEAT LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
○	14060	206.6(AFT)	-0.5LT	5880	16.0	289	IRP CLIMB
□	14200	206.6(AFT)	-0.5LT	5260	16.5	289	MIN POWER

NOTE: CLEAN CONFIGURATION

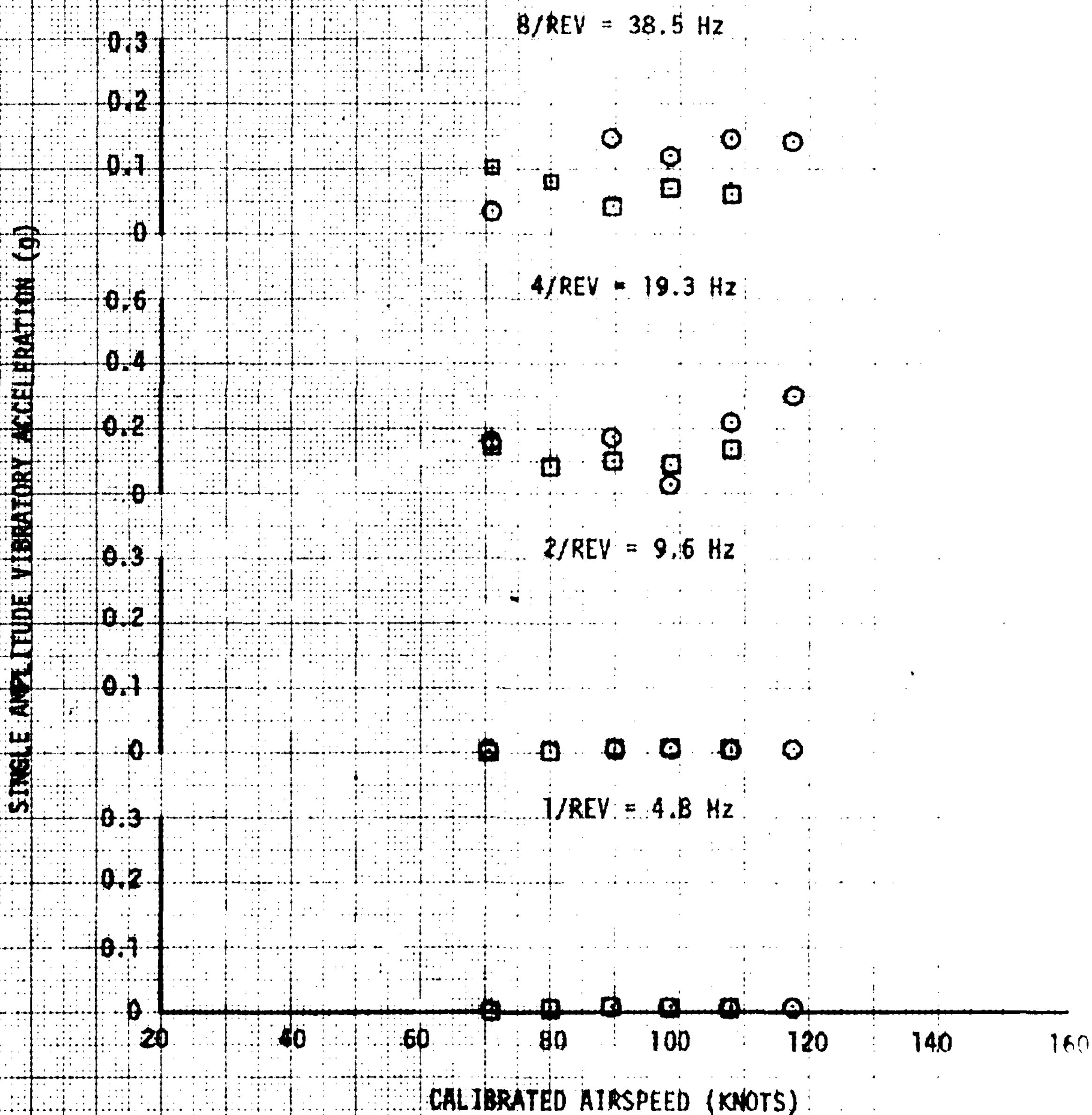


FIGURE 65
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
PILOT SEAT LONGITUDINAL

SYM	AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
○	14060	206.6(AFT)	-0.5LT	5880	16.0	289	IRP CLIMB
□	14200	206.6(AFT)	-0.5LT	5260	16.5	289	MIN POWER

NOTE: CLEAN CONFIGURATION

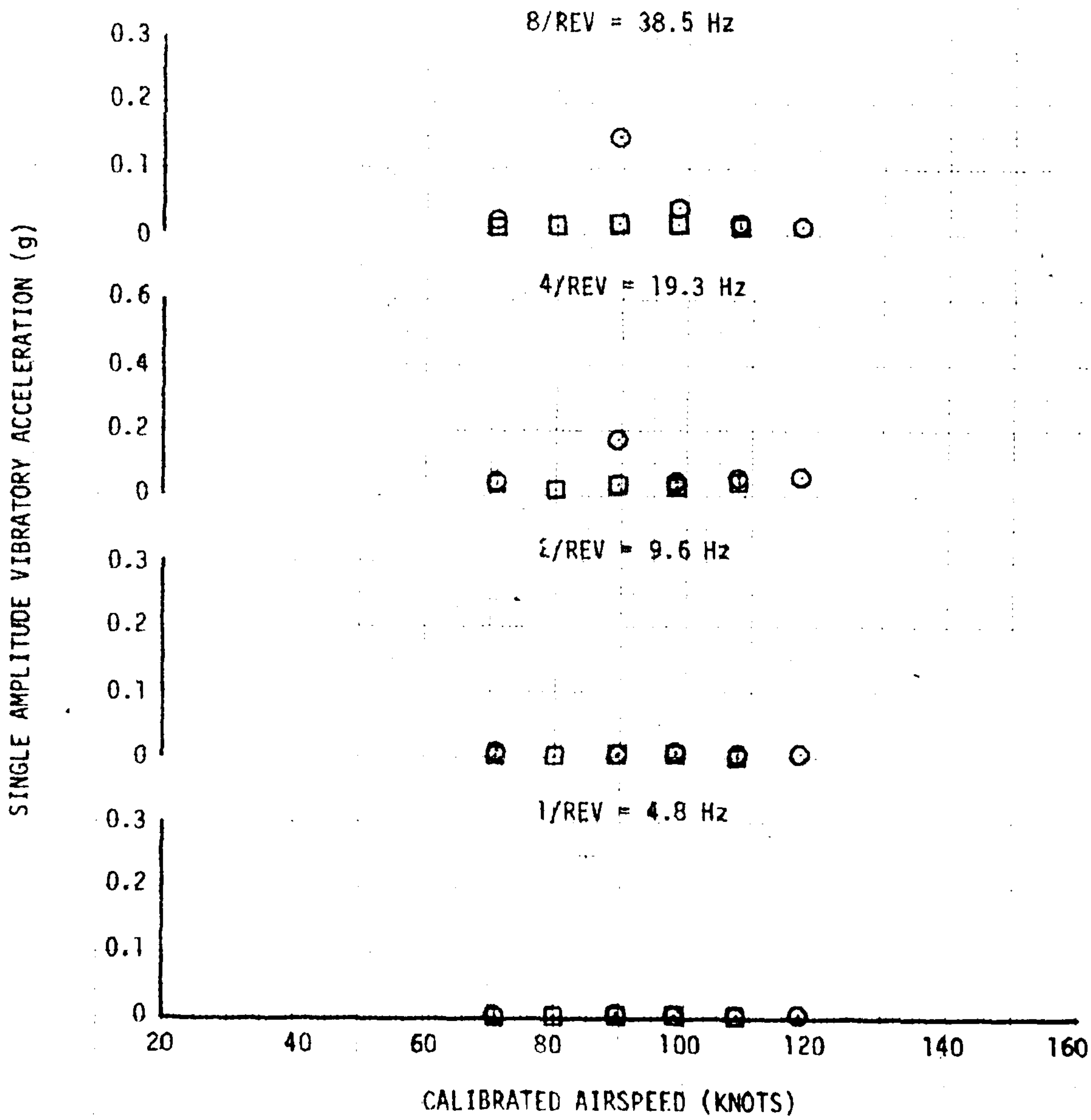


FIGURE 186
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
COPILOT SEAT VERTICAL

SYM	AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
○	14060	206.6(AFT)	-0.5LT	5880	16.0	289	IRP CLIMB
□	14200	206.6(AFT)	-0.5LT	5260	16.5	289	MIN POWER

NOTE: CLEAN CONFIGURATION

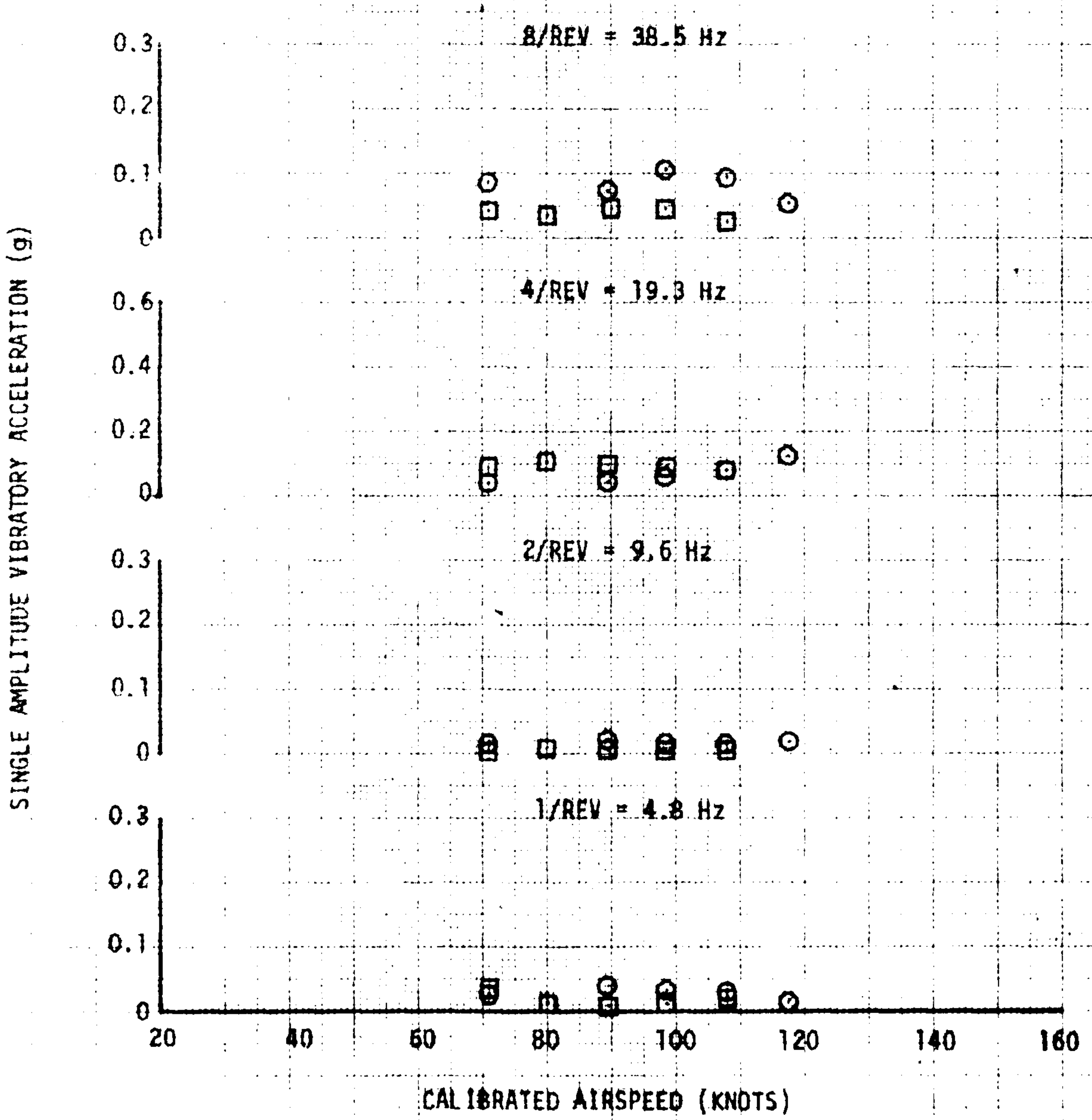


FIGURE 67
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
COPILOT SEAT LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
⊙	14060	206.6(AFT)	-0.5LT	5680	16.0	289	IRP CLIMB
⊡	14200	206.6(AFT)	-0.5LT	5260	16.5	289	MIN POWER

NOTE: CLEAN CONFIGURATION

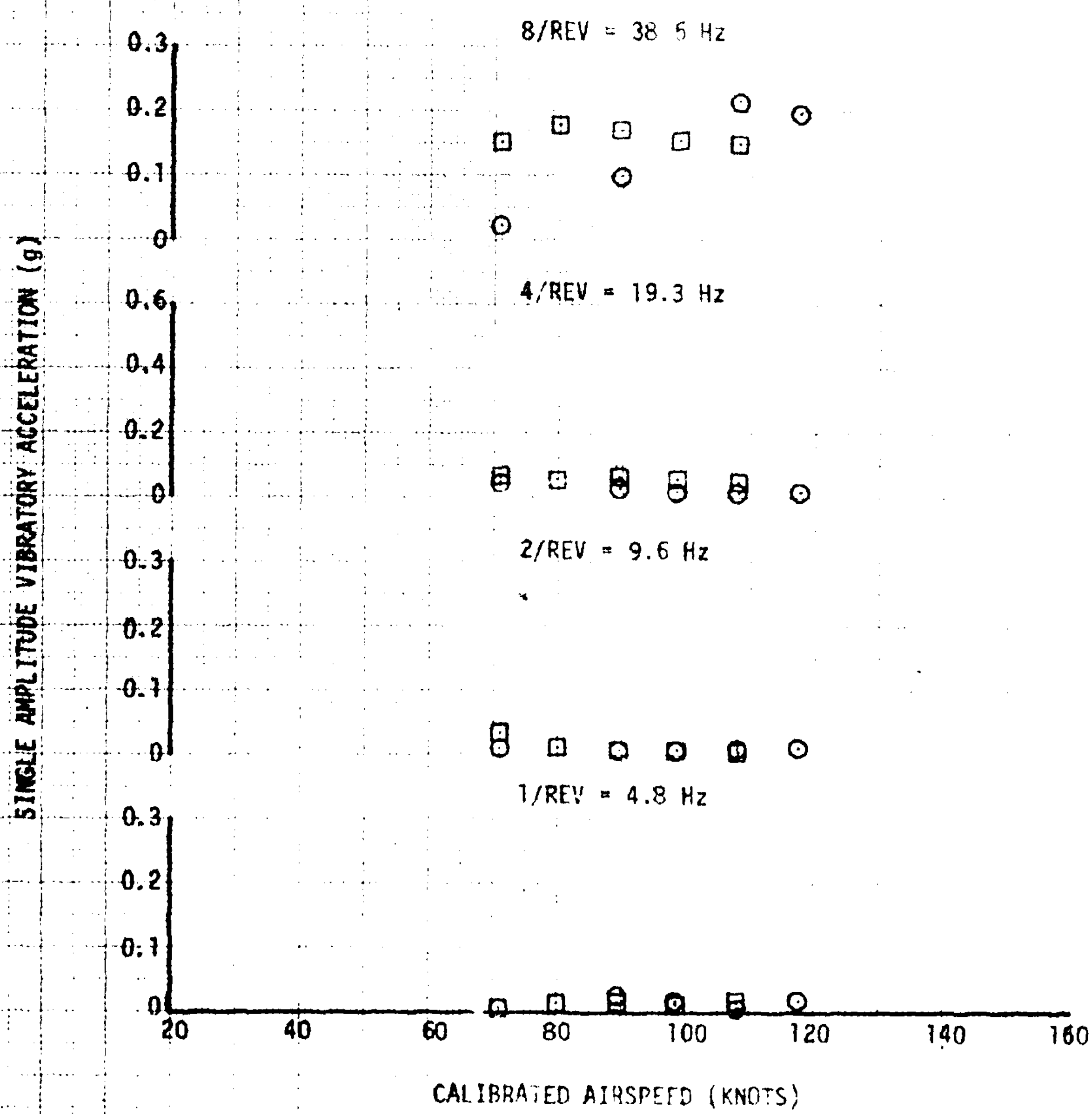


FIGURE 68
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
COPILOT SEAT LONGITUDINAL

SYM	AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
○	14060	206.6(AFT)	-0.5LT	5880	16.0	289	IRP CLIMB
□	14200	206.6(AFT)	-0.5LT	5260	16.5	289	MIN POWER

NOTE: CLEAN CONFIGURATION

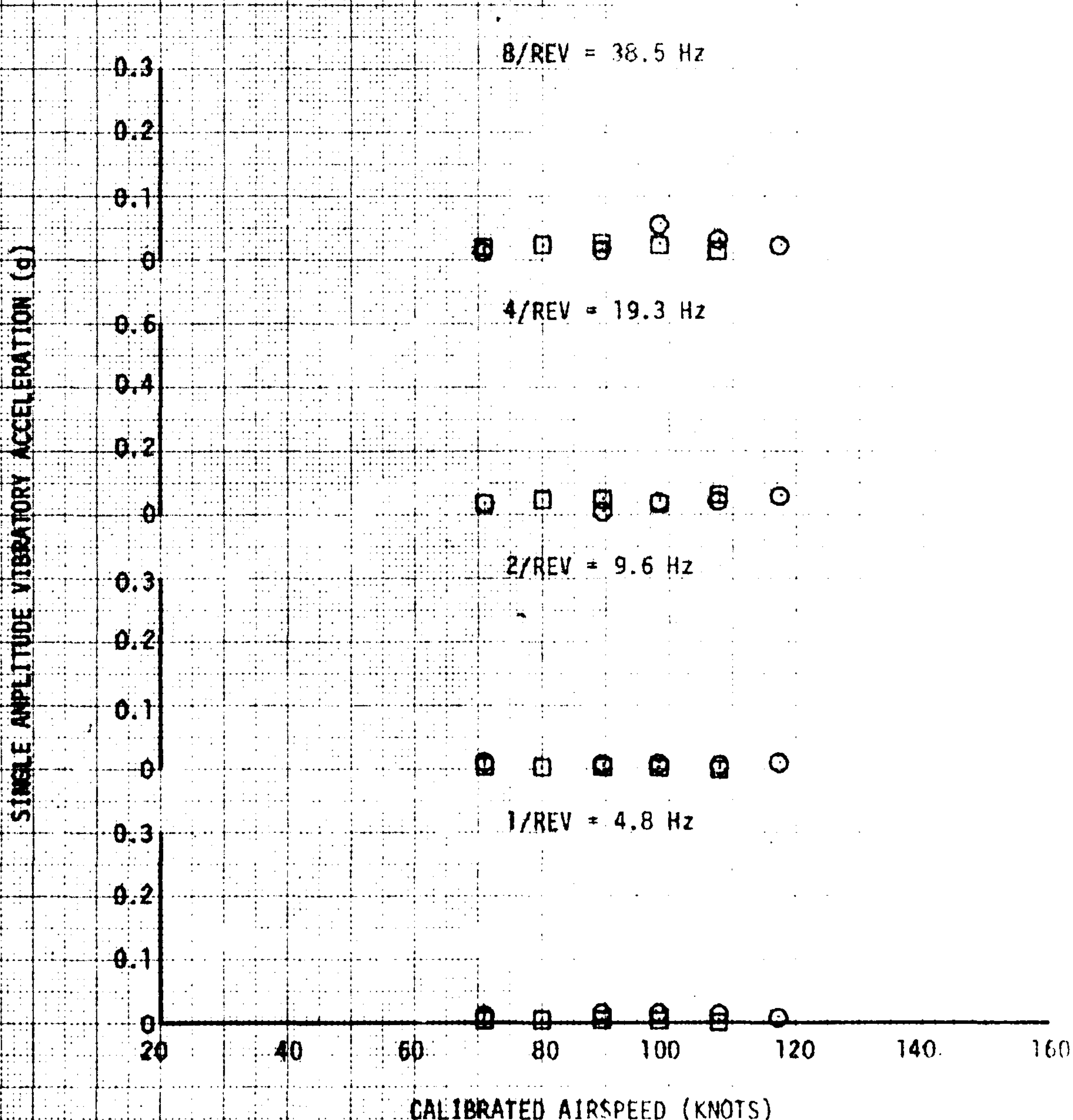


FIGURE 69
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
AIRCRAFT CG VERTICAL

SYM	AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
○	14060	206.6(AFT)	-0.5LT	5880	16.0	289	IRP CLIMB
□	14200	206.6(AFT)	-0.5LT	5260	16.5	289	MIN POWER

NOTE: CLEAN CONFIGURATION

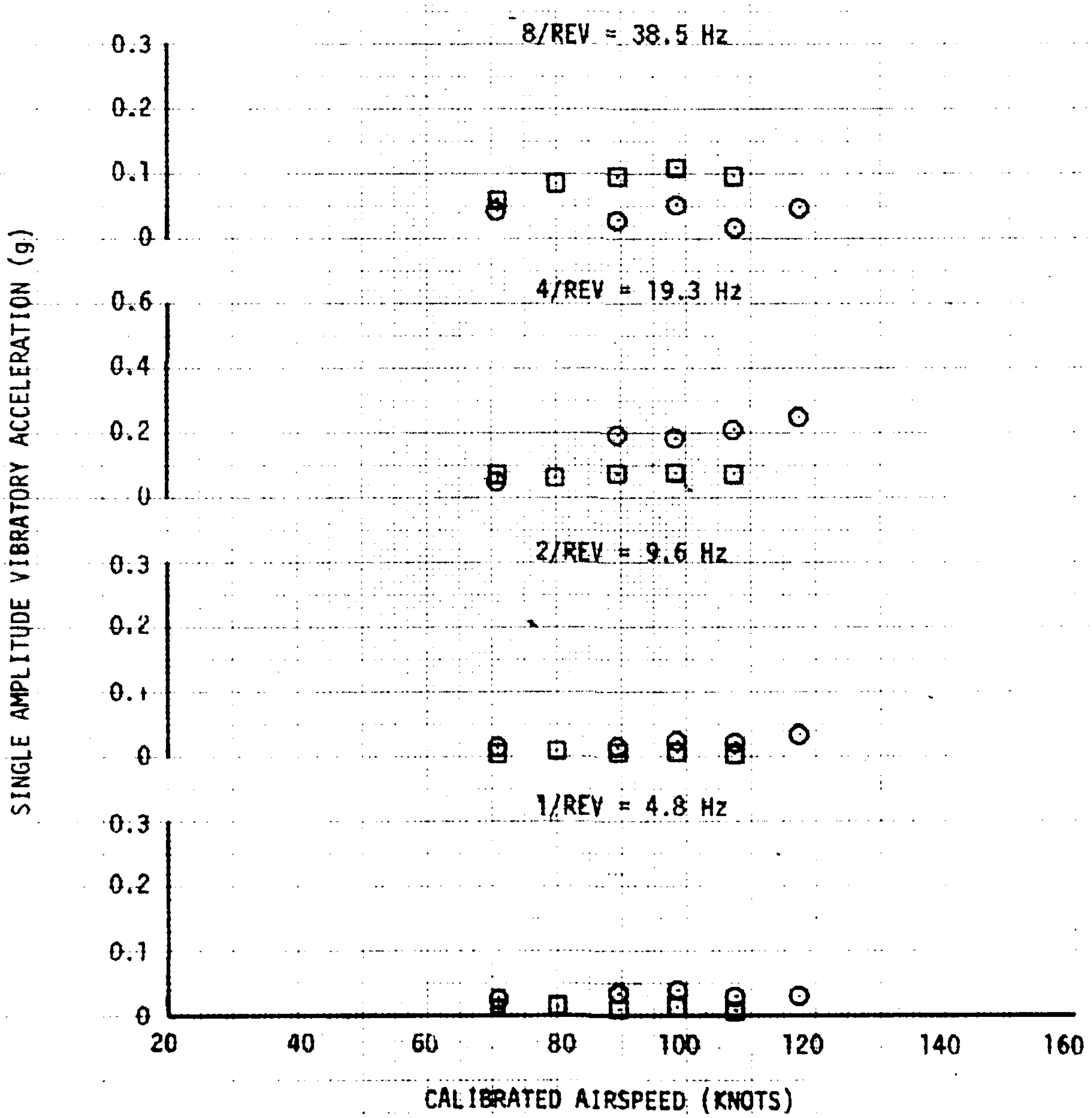


FIGURE 70

VIBRATION CHARACTERISTICS

YAH-64 USA S/N 74-22248

AIRCRAFT CG LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
○	14060	206.6(AFT)	-0.5LT	5880	16.0	289	IRP CLIMB
□	14200	206.6(AFT)	-0.5LT	5260	16.5	289	MIN POWER

NOTE: CLEAN CONFIGURATION

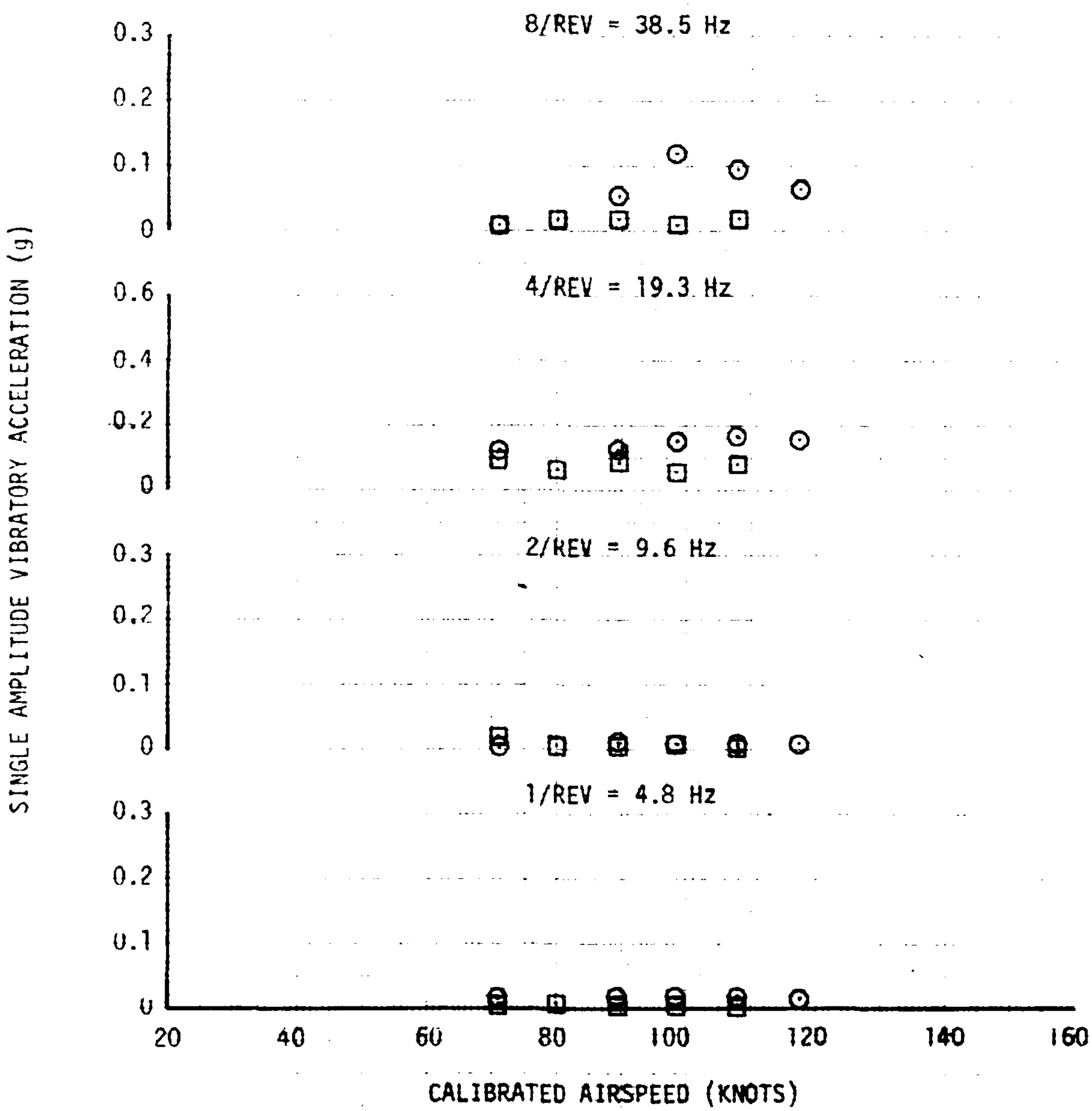


FIGURE 71
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
AIRCRAFT CG LONGITUDINAL

SYM	AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
○	14060	206.6(AFT)	-0.5LT	5880	16.0	289	IRP CLIMB
□	14200	206.6(AFT)	-0.5LT	5260	16.5	289	MIN POWER

NOTE: CLEAN CONFIGURATION

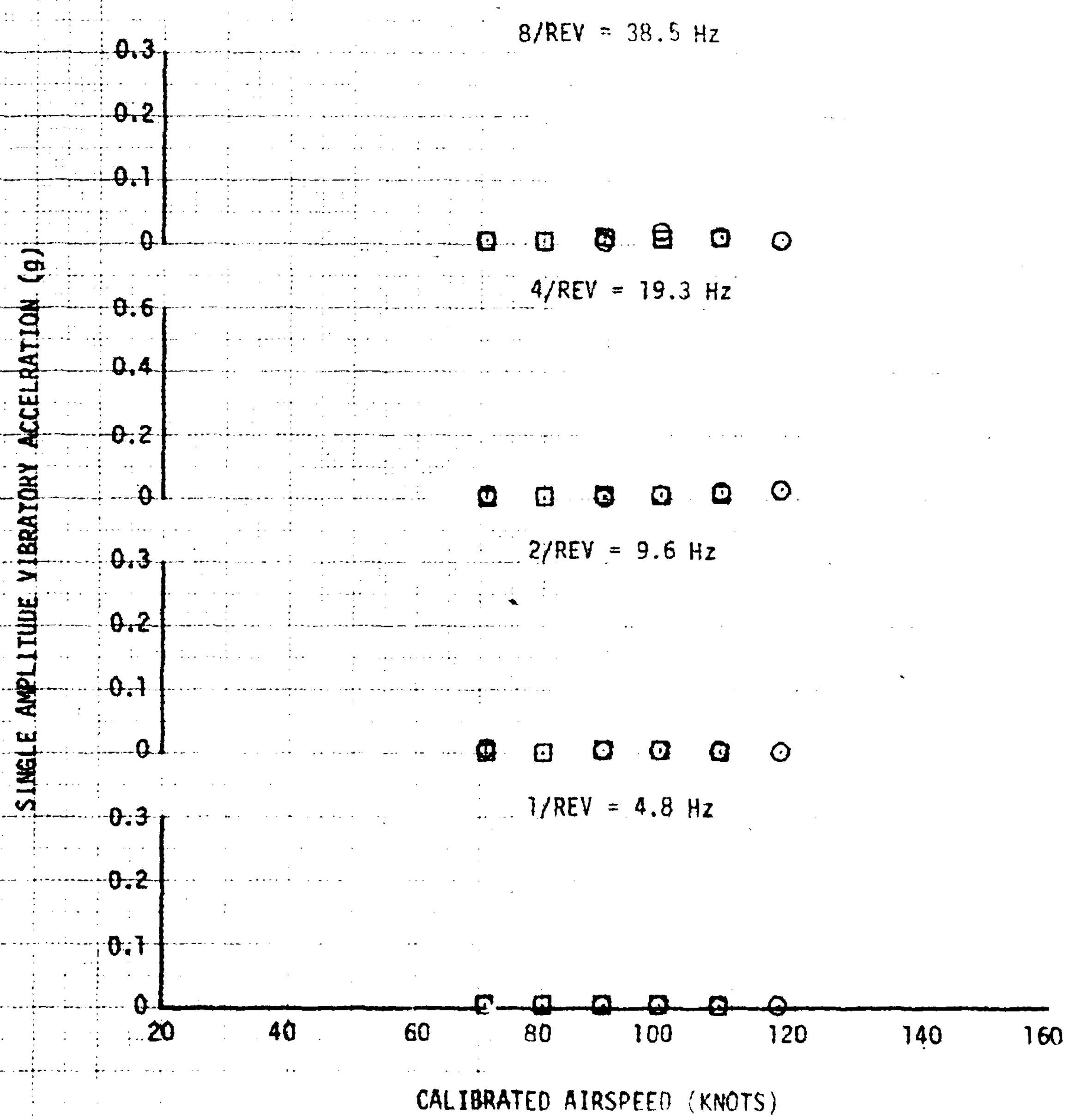


FIGURE 72
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
PILOT SEAT VERTICAL

AV GROSS WEIGHT (LB)	AV CG LOCATION LONG (FS)	AV CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AV ROTOR SPEED (RPM)	FLIGHT CONDITION
15180	200.0(FWD)	-0.5LT	140	11.0	289	SIDEWARD

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

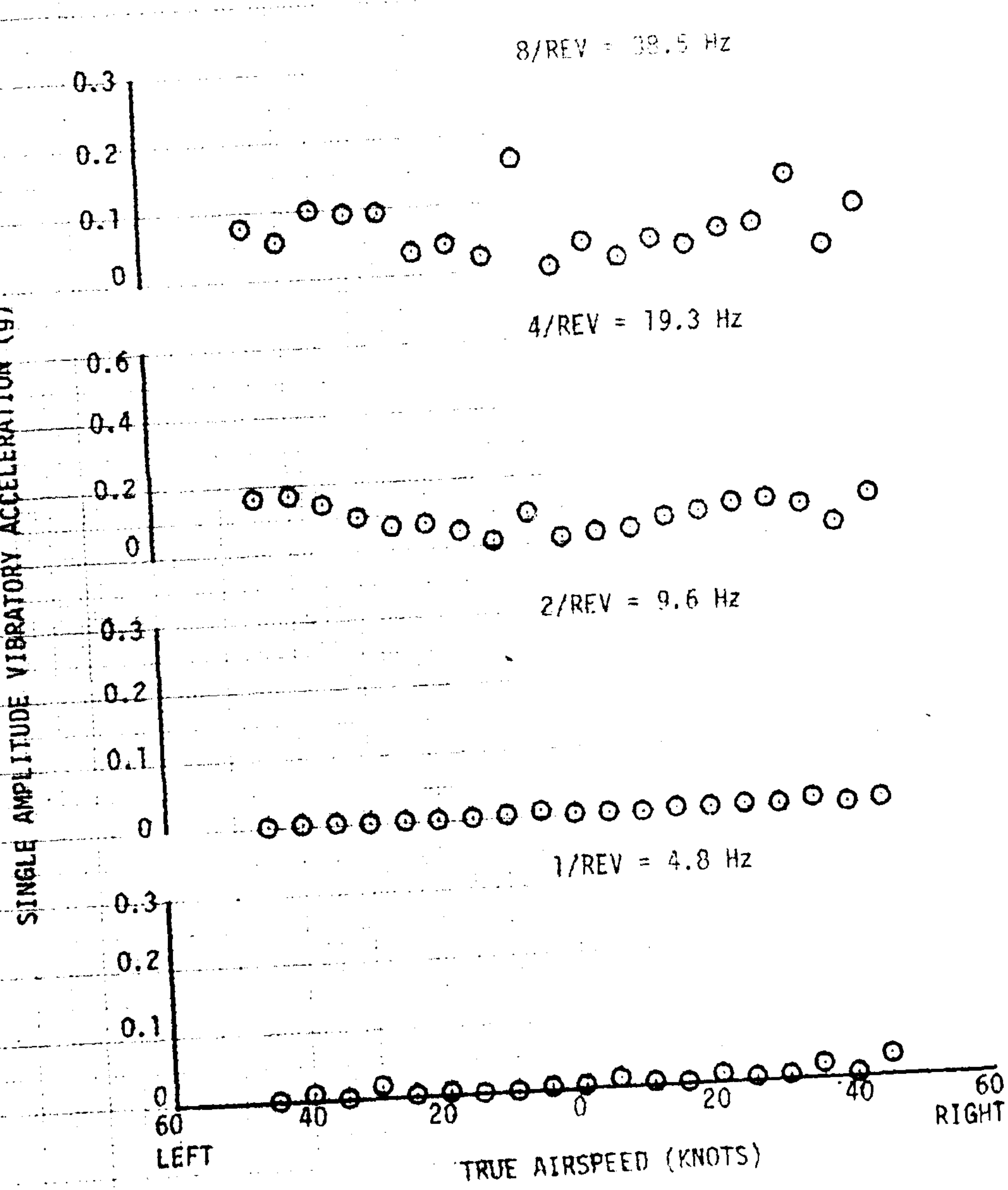


FIGURE 73
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
PILOT SEAT LATERAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15180	200.0(FWD)	-0.5LT	140	11.0	289	SIDEWARD

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

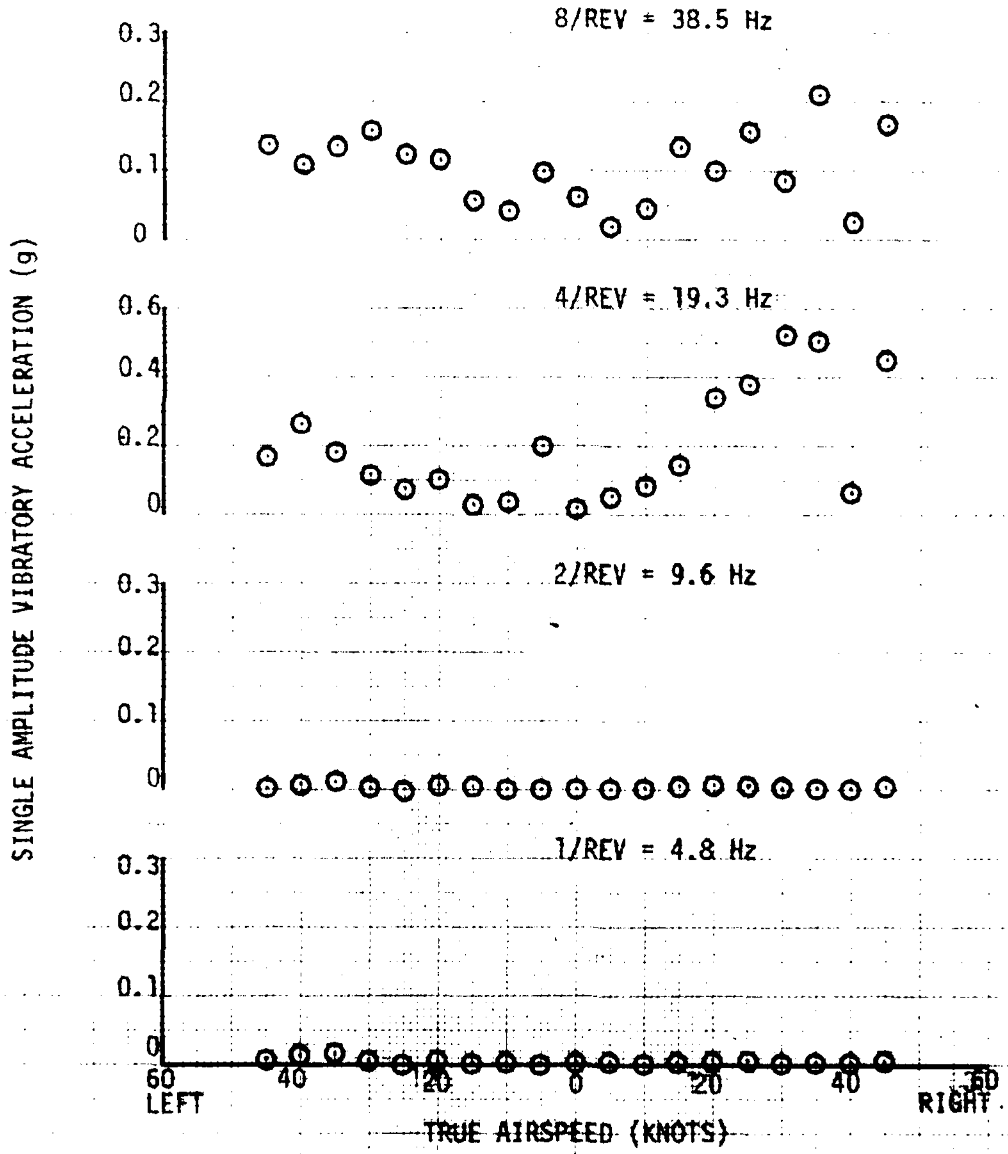


FIGURE 74
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
PILOT SEAT LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15180	200.0(FWD)	-0.5LT	140	11.0	289	SIDEWARD

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

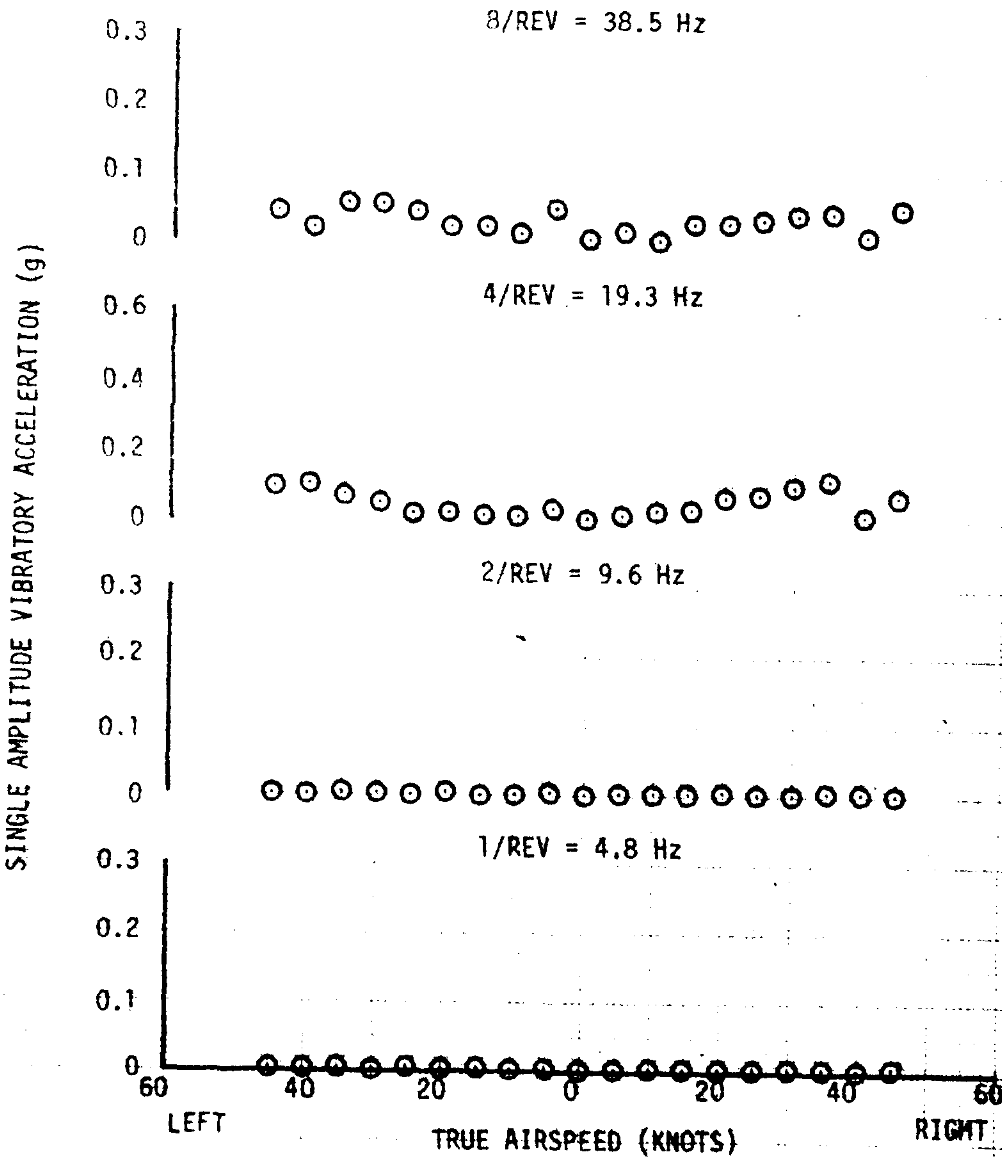


FIGURE 75
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
COPILOT SEAT VERTICAL

AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15180	200.0(FWD)	-0.5LT	140	11.0	289	SIDEWARD

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

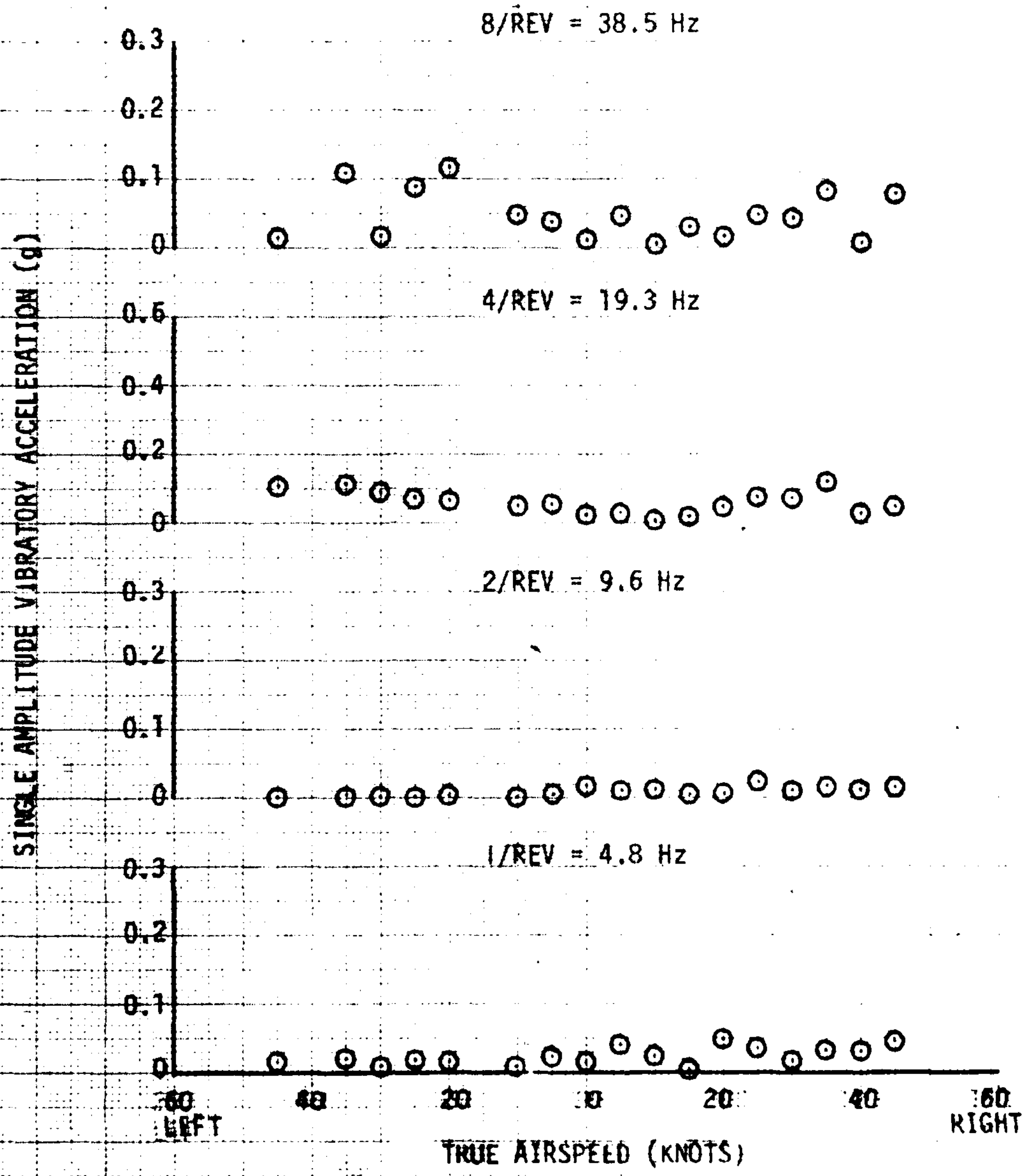


FIGURE 76
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
COPILOT SEAT LATERAL

AVG GROSS WEIGHT (LB)	AVG LOCATION LONG (FS)	AVG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15180	200.0(FWD)	-0.5LT	140	11.0	289	SIDEWARD

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

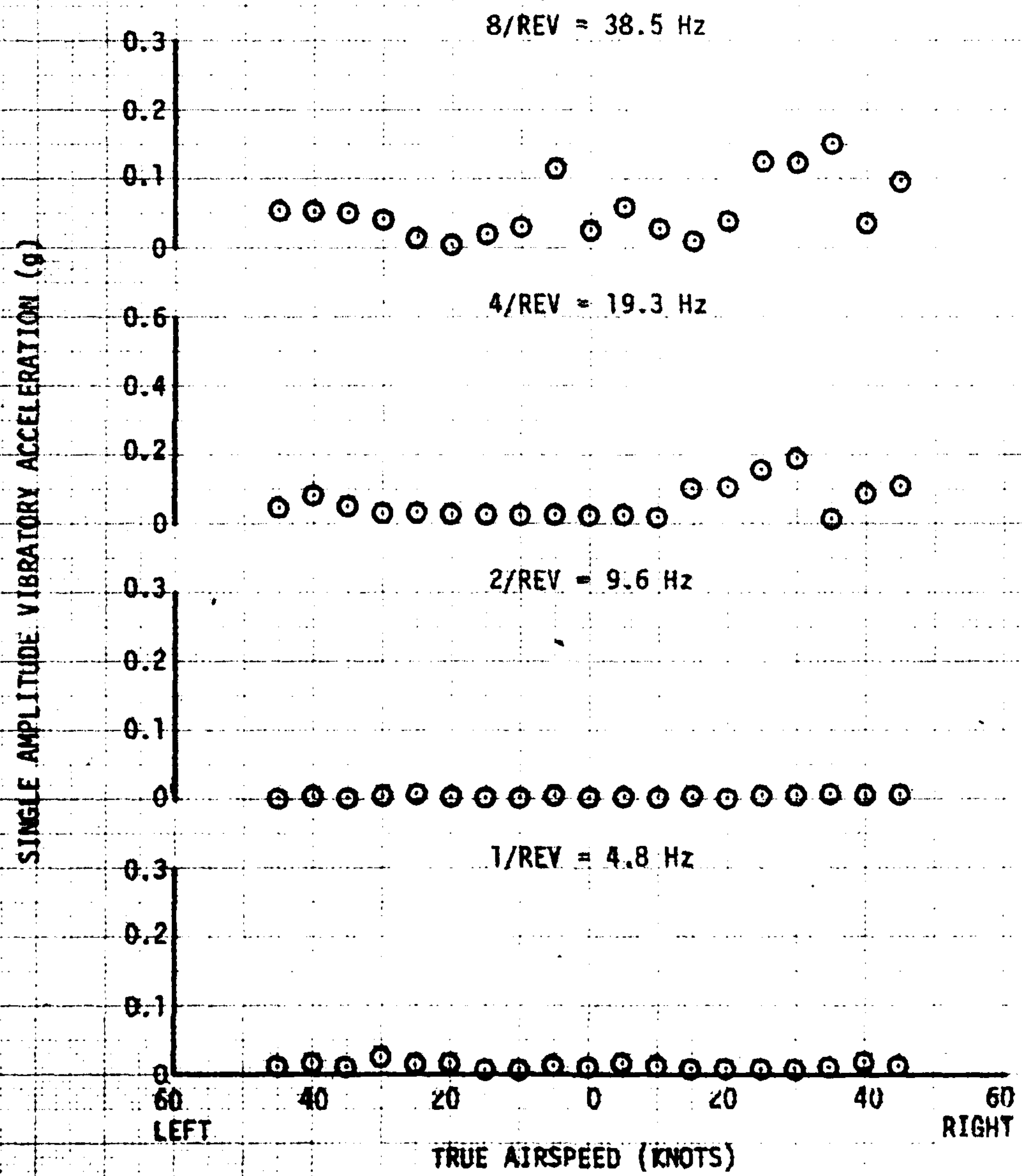


FIGURE 77
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
COPILOT SEAT LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15180	200.0(FWD)	-0.5LT	140	11.0	289	SIDEWARD

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

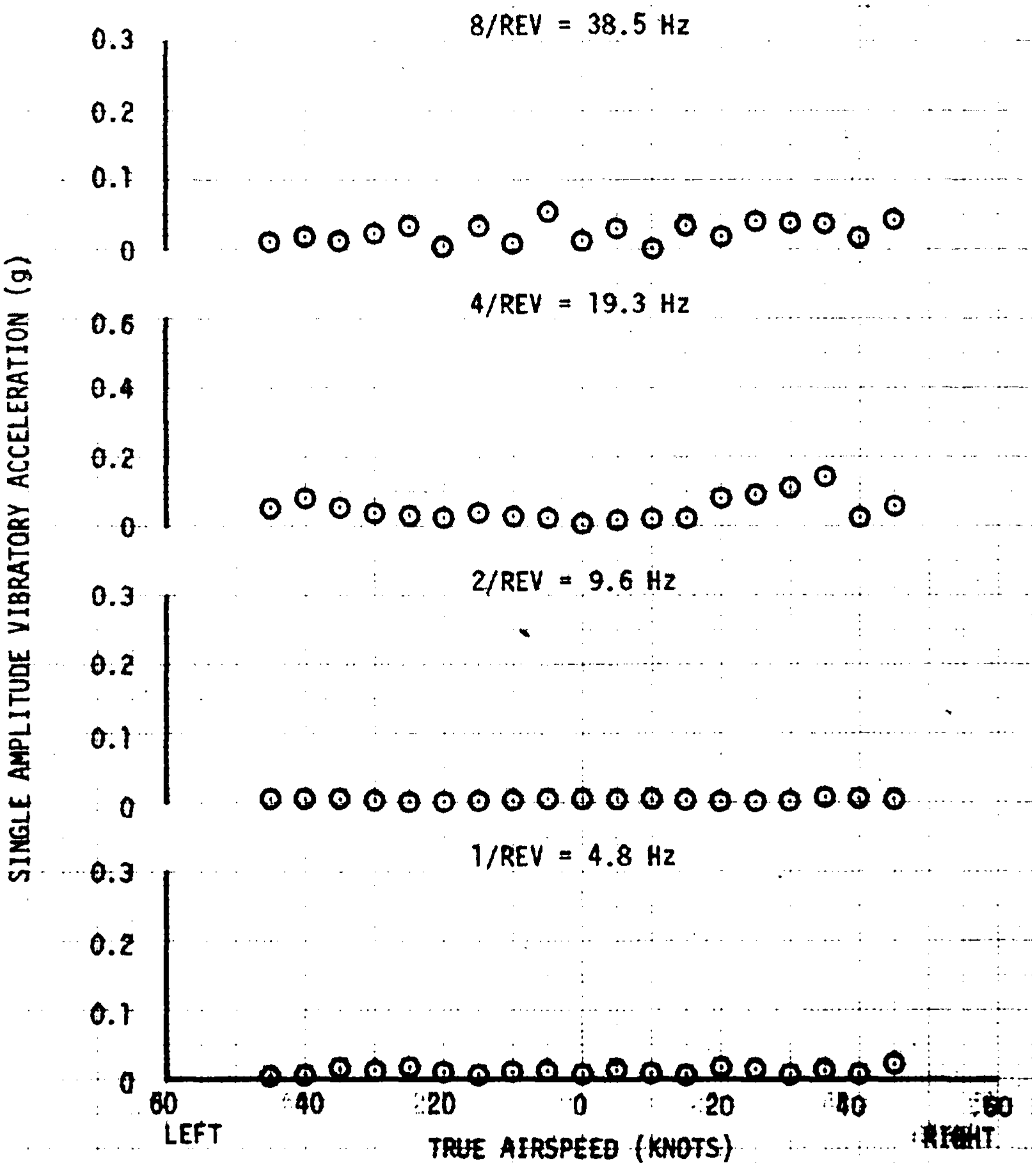


FIGURE 78
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
AIRCRAFT CG VERTICAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15180	200.0(FWD)	-0.5LT	140	11.0	289	SIDEWARD

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

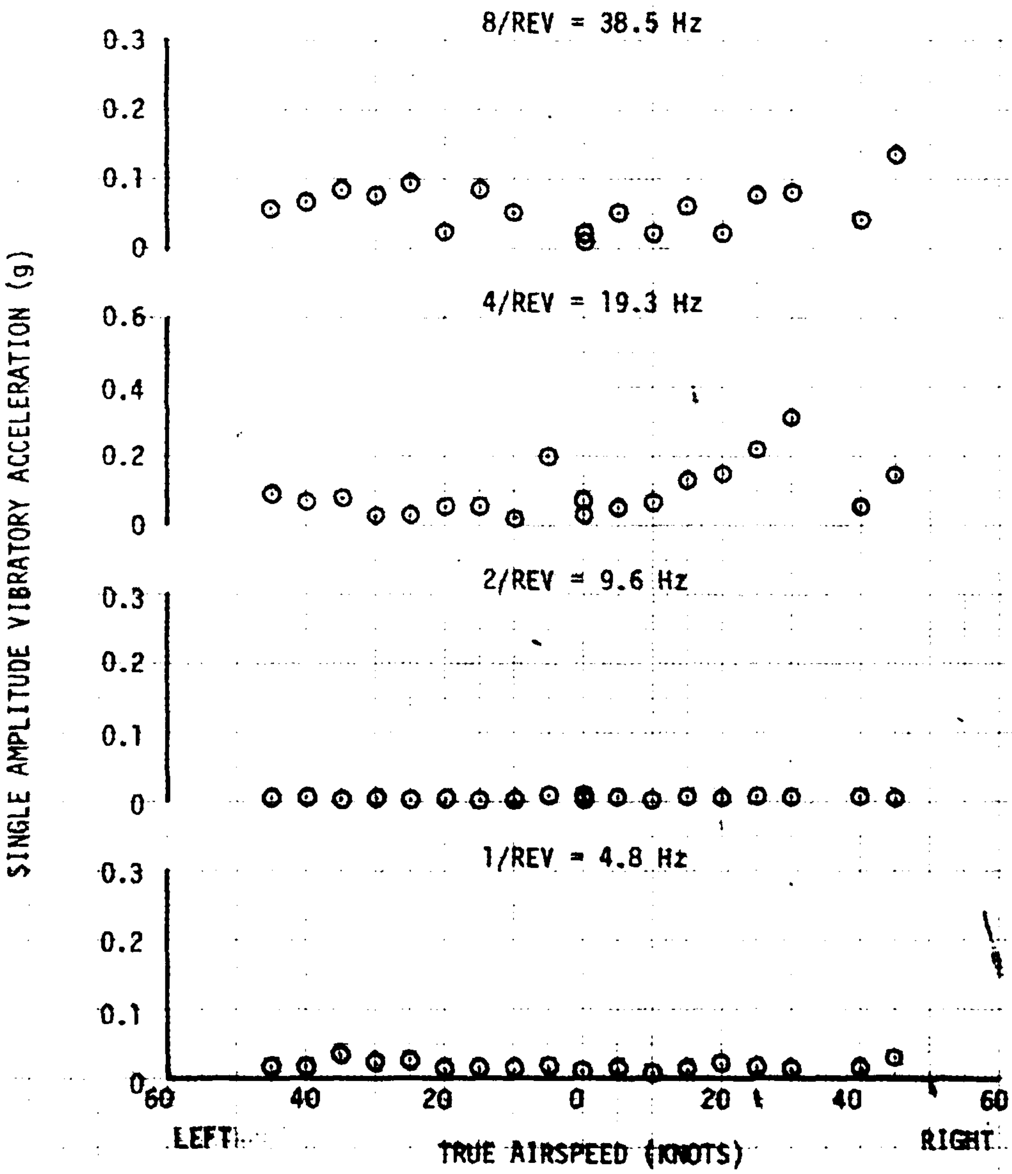


FIGURE 79
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
AIRCRAFT CG LATERAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15180	200.0(FWD)	-0.5LT	140	11.0	289	SIDEWARD

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

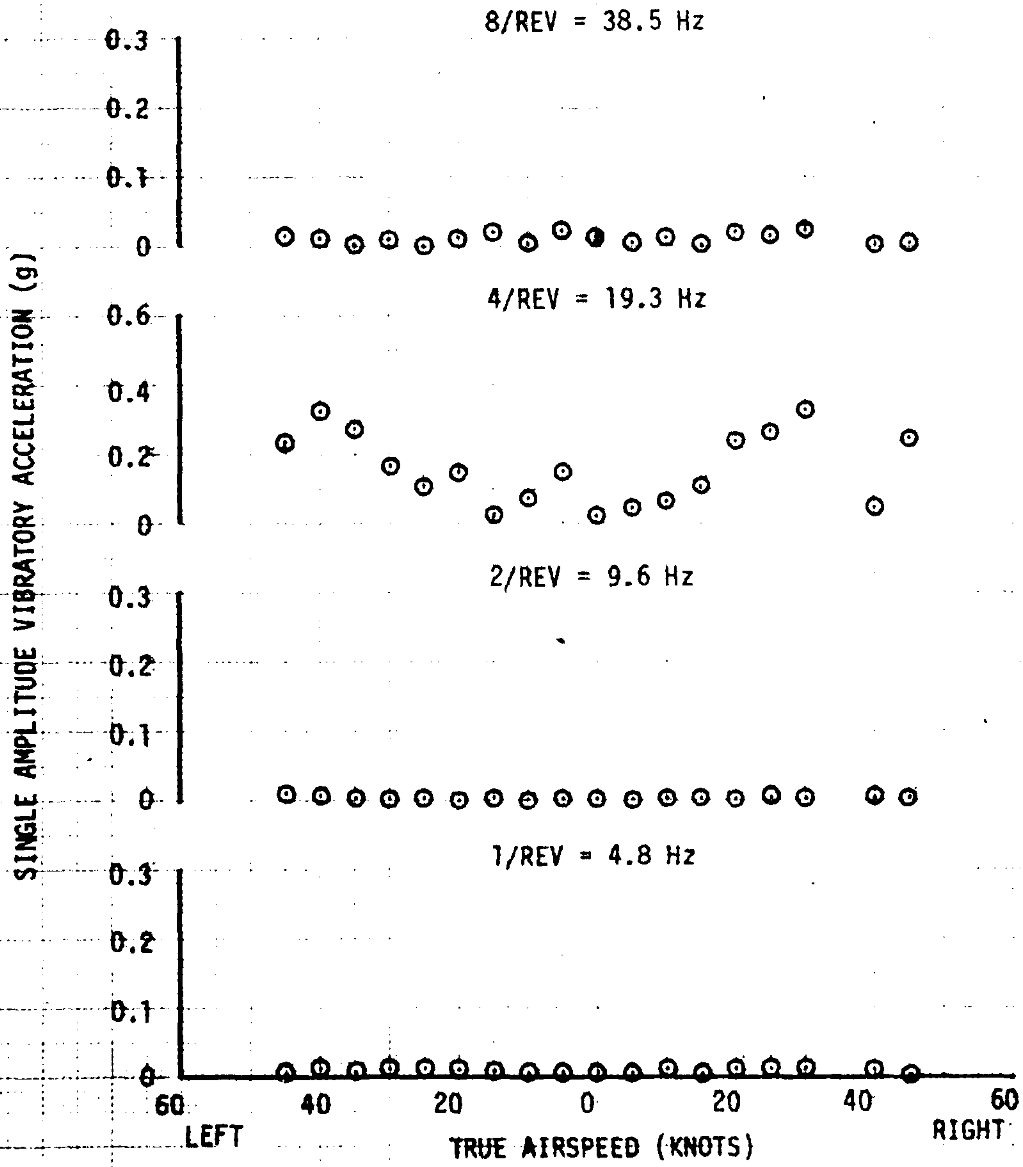


FIGURE 80
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
AIRCRAFT CG LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15180	200.0(FWD)	-0.5LT	140	11.0	289	SIDEWARD

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

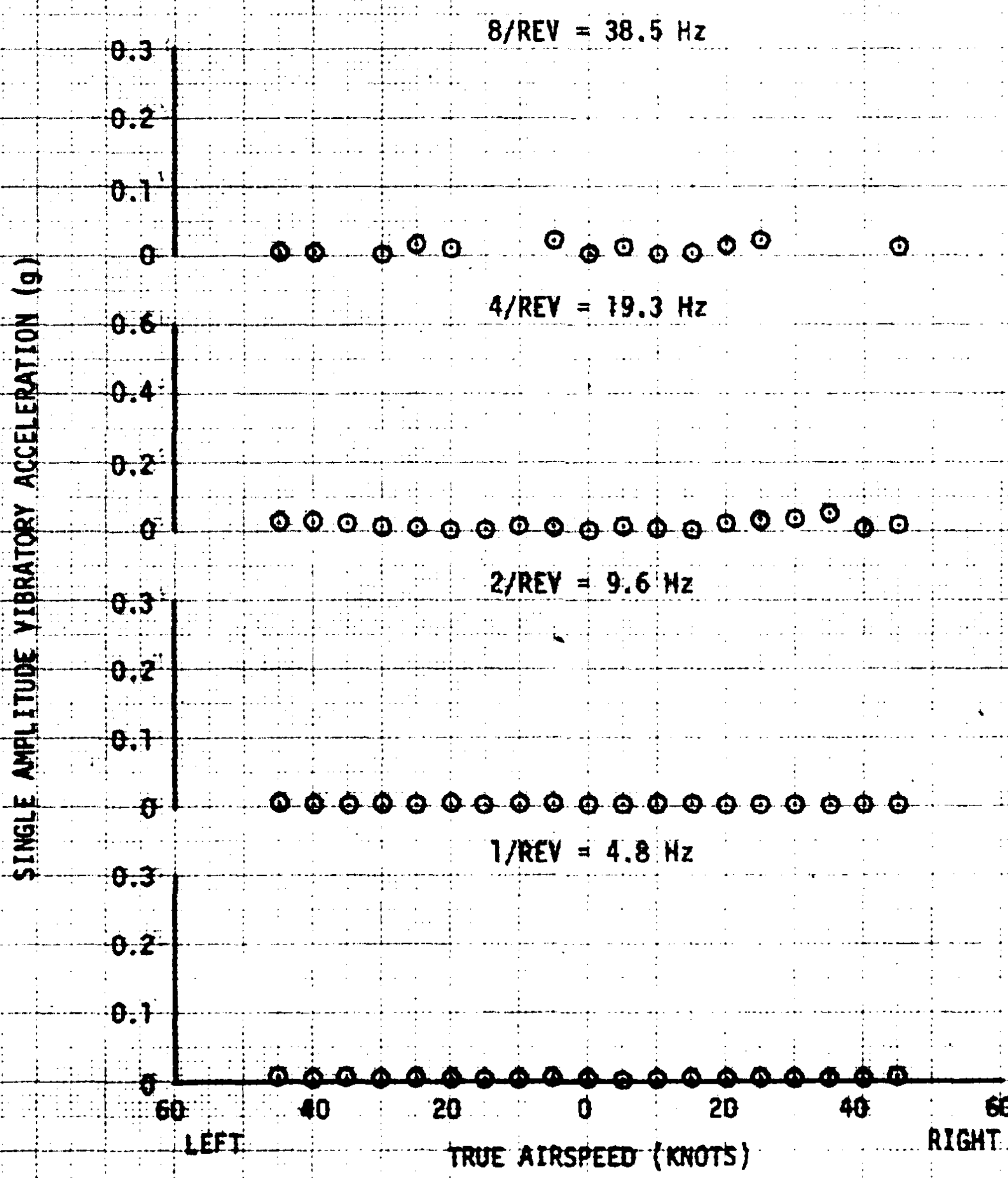


FIGURE [illegible]

VIBRATION CHARACTERISTICS

YAH-64 USA S/N 74-22249

PILOT SEAT VERTICAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15100	200.0(FWD)	-0.6LT	120	11.5	289	LOW SPEED

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

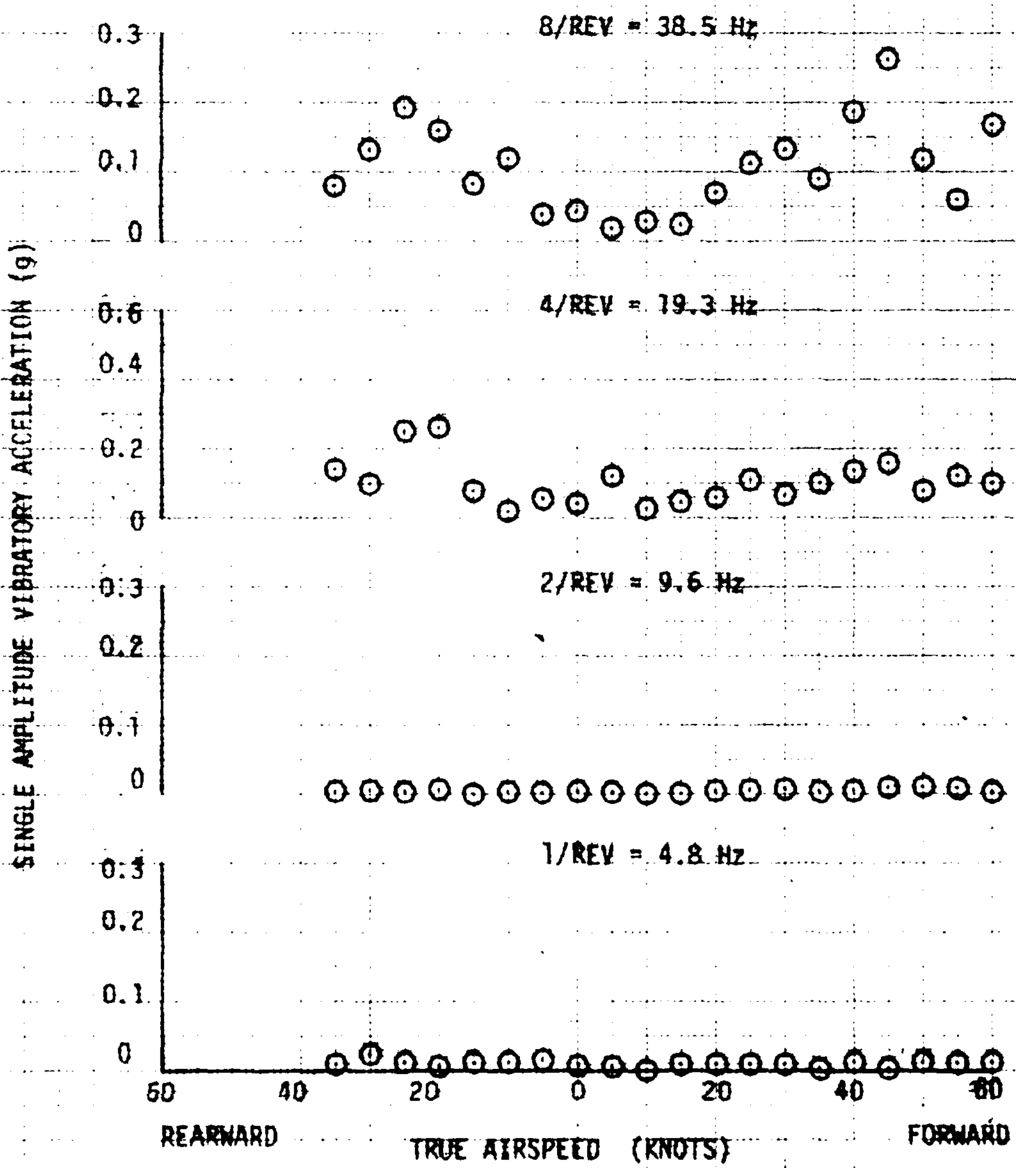


FIGURE 82

VIBRATION CHARACTERISTICS

YAH-64 USA S/N 74-22249

PILOT SEAT LATERAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (^{o}C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15100	200.0(FWD)	-0.6LT	120	11.5	289	LOW SPEED

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

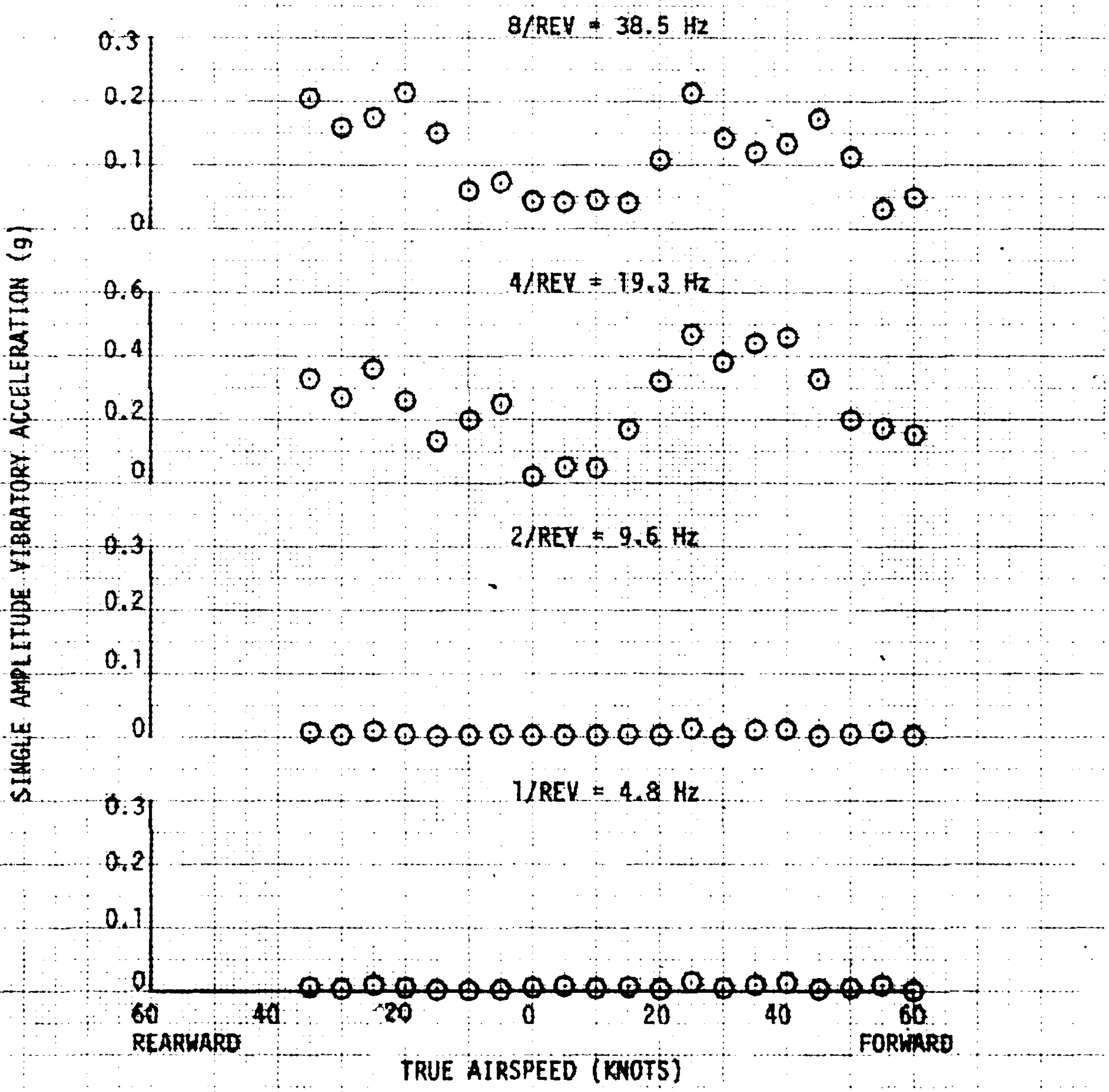


FIGURE B3
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
PILOT SEAT LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15100	200.0(FWD)	-0.6LT	120	11.5	289	LOW SPEED

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

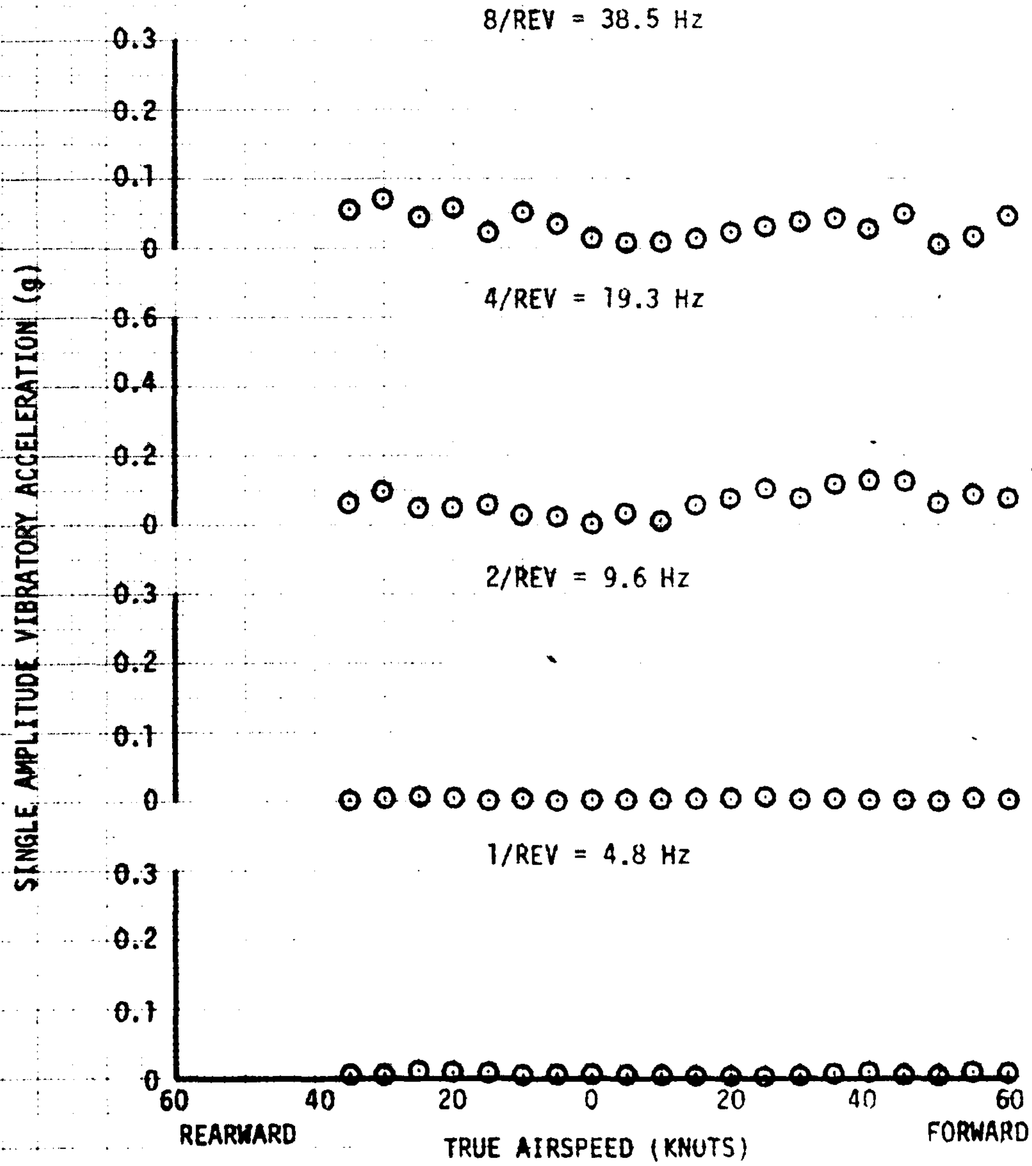


FIGURE 84
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
COPILOT SEAT VERTICAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15100	200.0(FWD)	-0.6LT	120	11.5	289	LOW SPEED

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

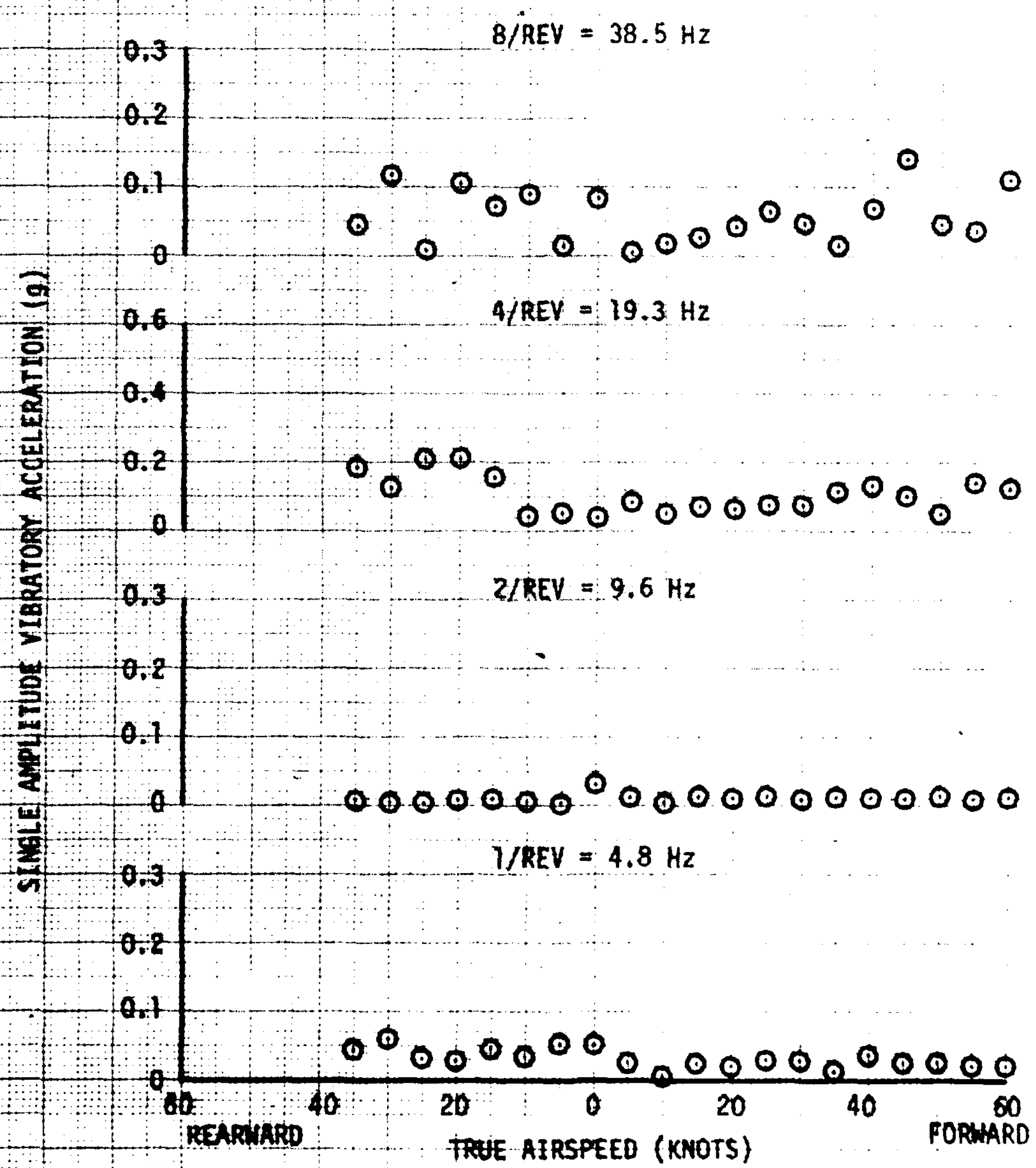


FIGURE 86
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
COPILOT SEAT LATERAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15100	200.0(FWD)	-0.6LT	120	11.5	289	LOW SPEED

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

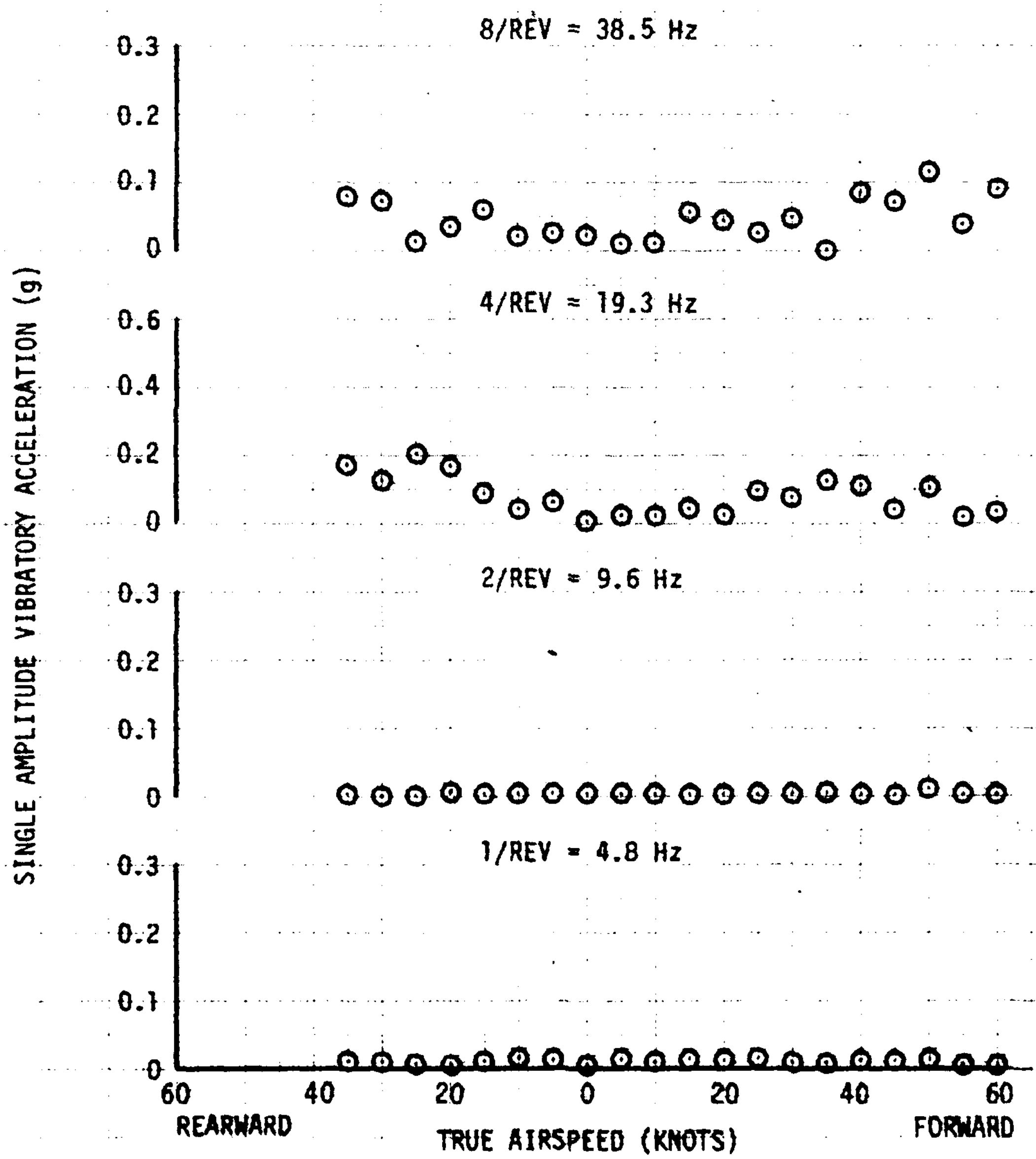


FIGURE B6
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
COPILOT SEAT LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15100	200.0(FWD)	-0.6LT	120	11.5	289	LOW SPEED

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

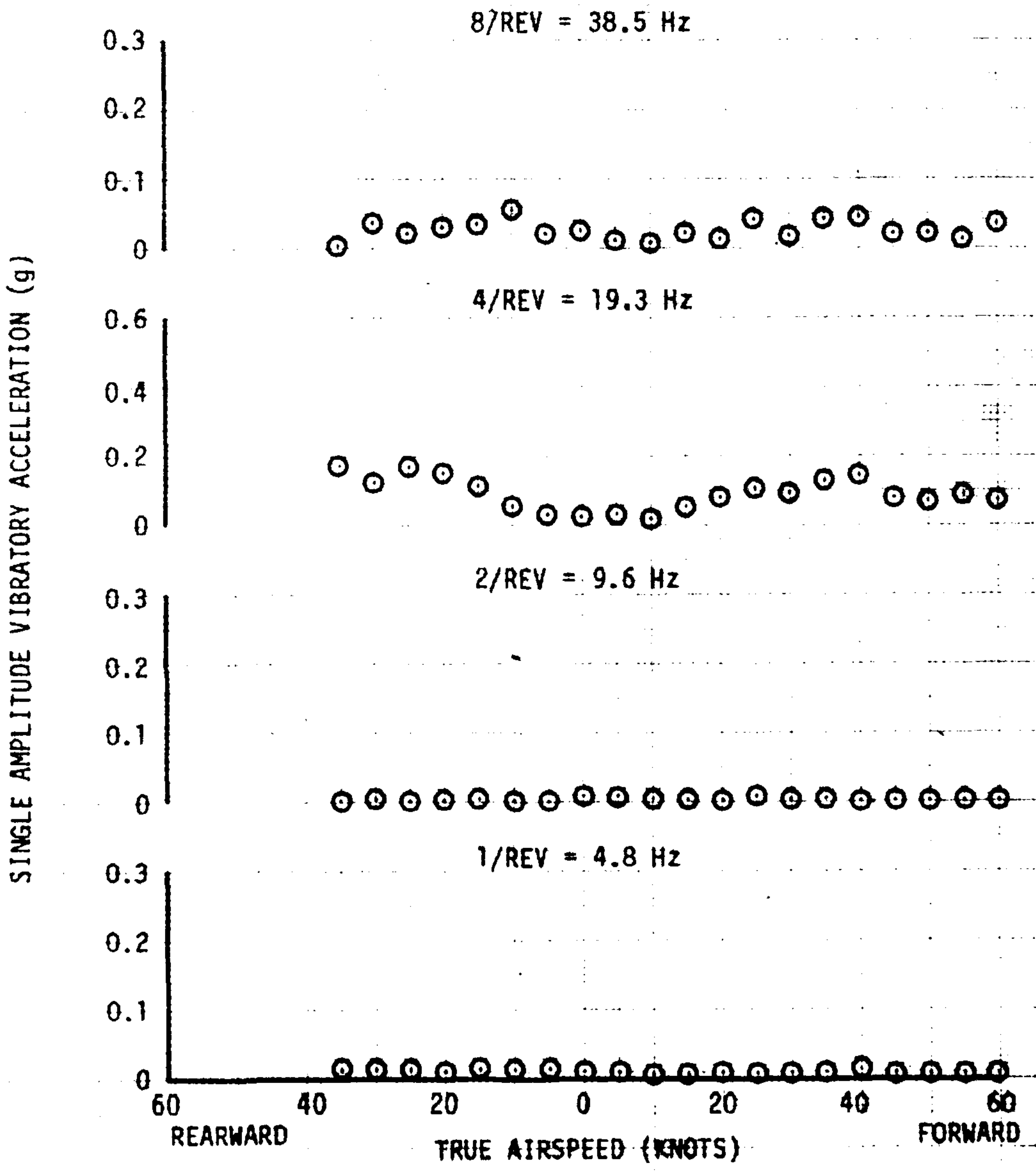


FIGURE 87
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
AIRCRAFT CG VERTICAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15100	200.0(FWD)	-0.6LT	120	11.5	289	LOW SPEED

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

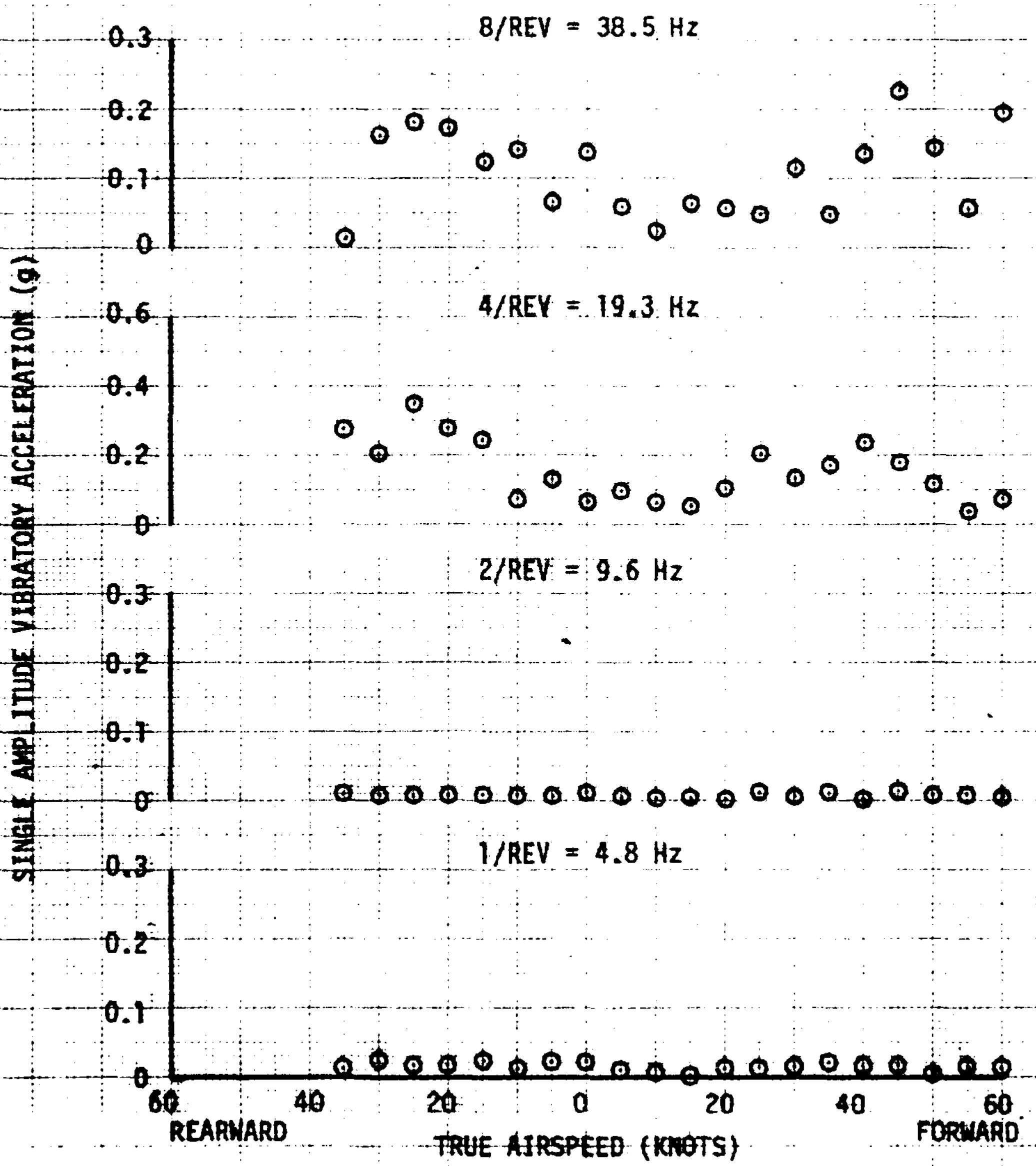


FIGURE 88
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
AIRCRAFT CG LATERAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15100	200.0(FWD)	-0.6LT	120	11.5	289	LOW SPEED

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

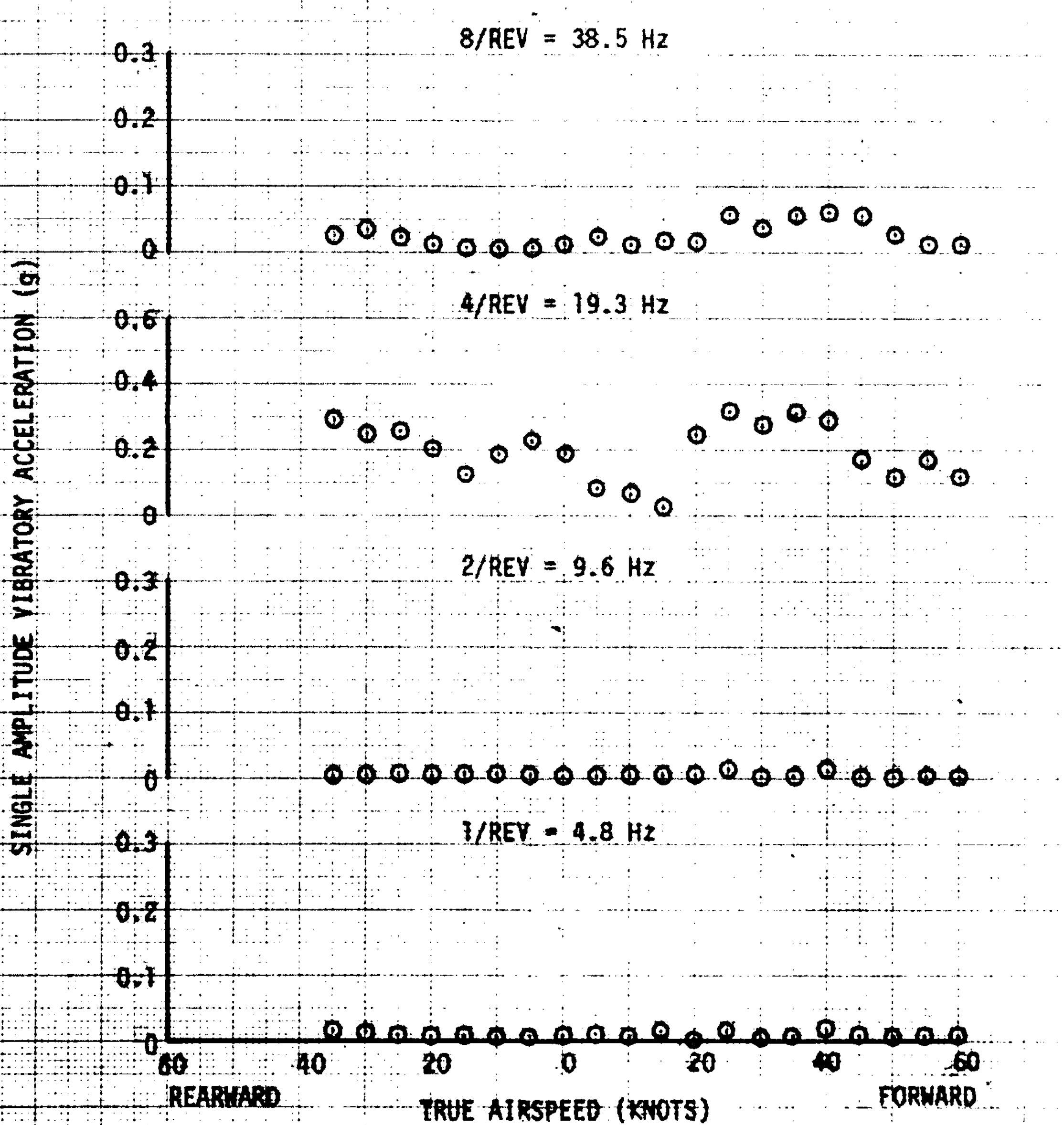


FIGURE 89
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22249
AIRCRAFT CG LONGITUDINAL

AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION
15100	200.0(FWD)	-0.6LT	120	11.5	289	LOW SPEED

NOTES: 1. CLEAN CONFIGURATION
2. WHEEL HEIGHT = 15 FEET

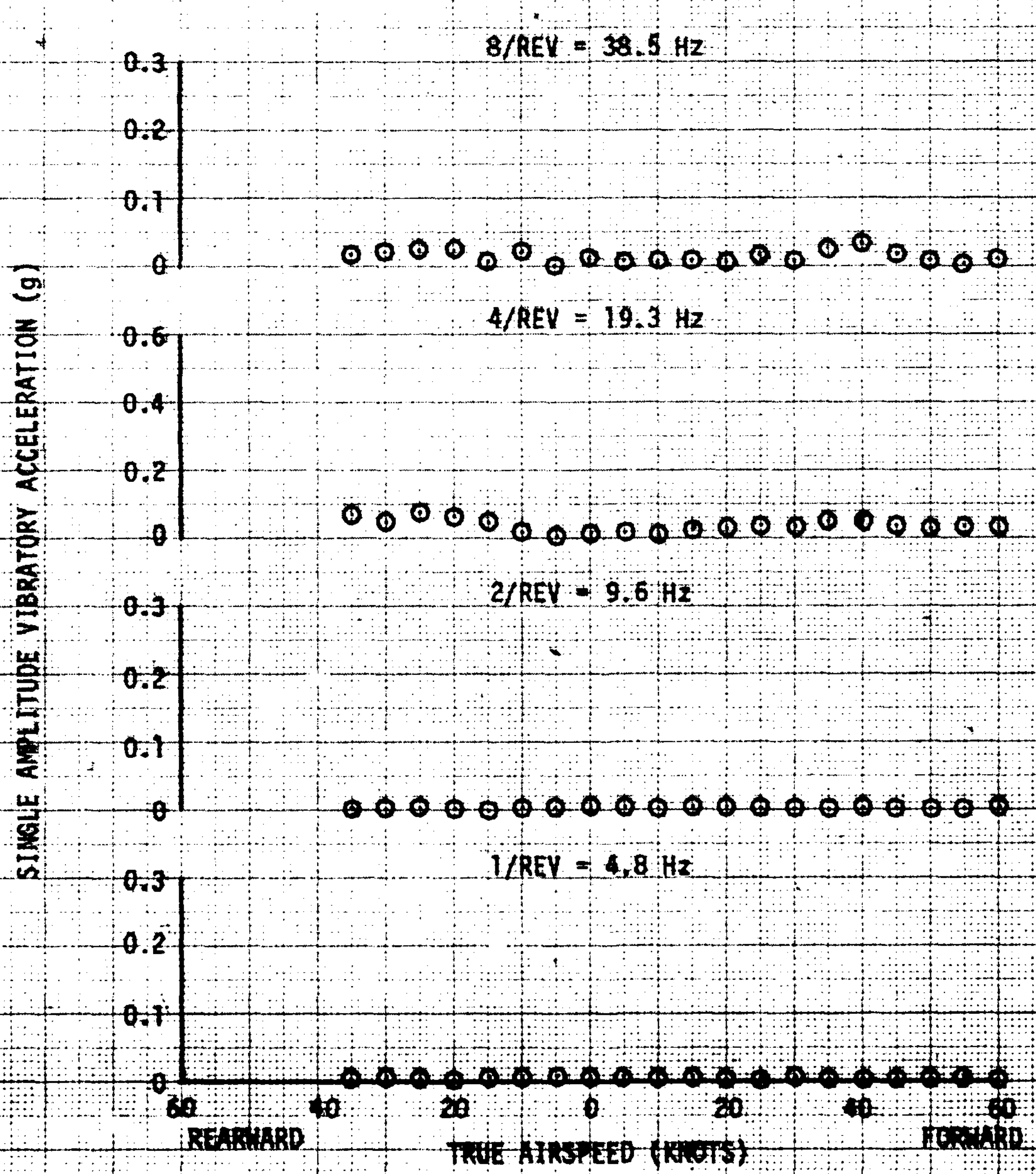


FIGURE 90
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
PILOT SEAT VERTICAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
O	13920	206.7(AFT)	-0.6 LT	5180	14.5	289	RT TURN	134
□	14120	206.6(AFT)	-0.5 LT	5160	14.5	289	LT TURN	134

NOTE: CLEAN CONFIGURATION

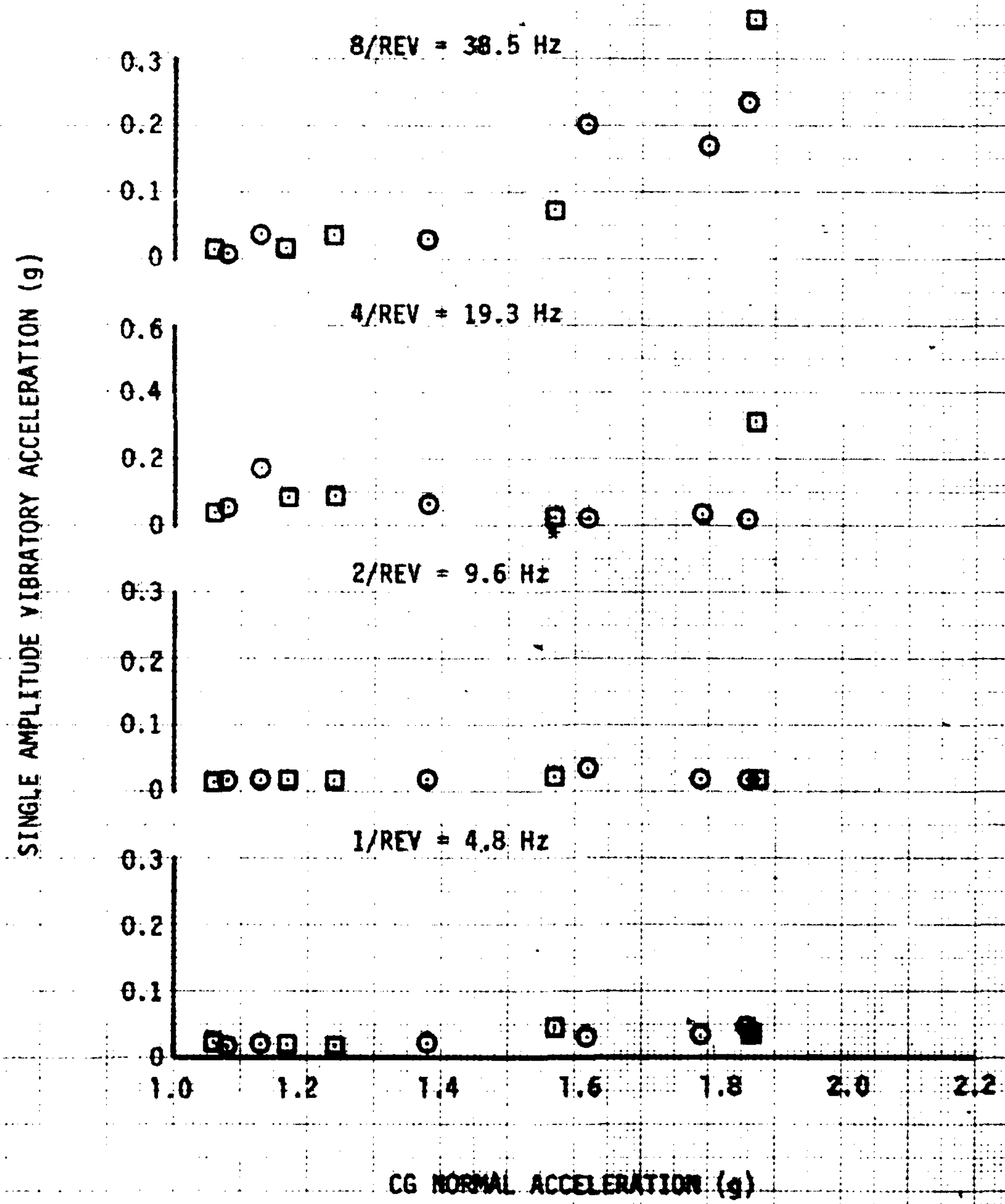


FIGURE 91
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
PILOT SEAT LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
○	13920	206.7(AFT)	-0.6 LT	5180	14.5	289	RT TURN	134
□	14120	206.5(AFT)	-0.5 LT	5160	14.5	289	LT TURN	134

NOTE: CLEAN CONFIGURATION

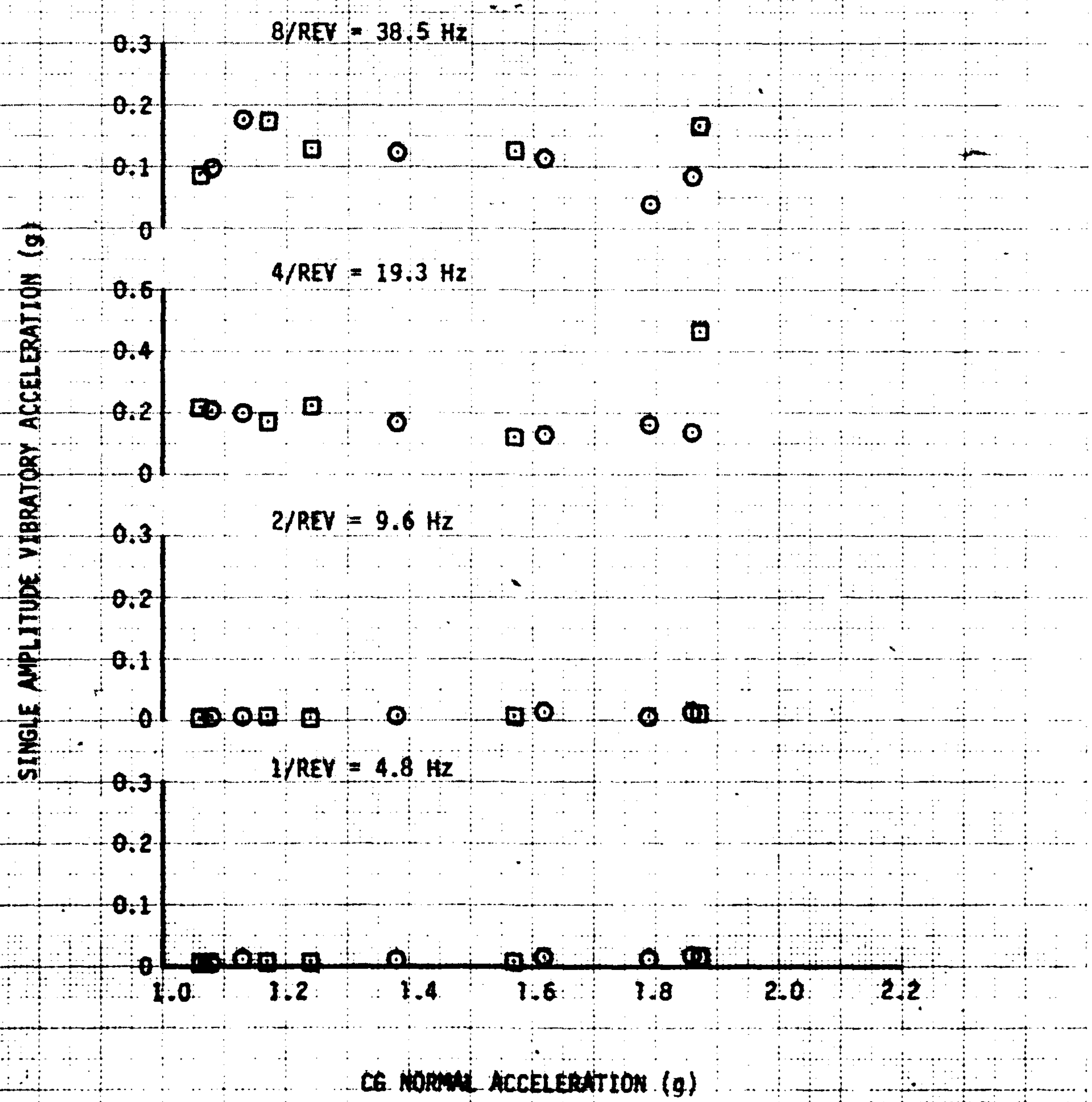


FIGURE 92
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
PILOT SEAT LONGITUDINAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
O	13920	206.7(AFT)	-0.6 LT	5180	14.5	289	RT TURN	134
□	14120	206.6(AFT)	-0.5 LT	5160	14.5	289	LT TURN	134

NOTE: CLEAN CONFIGURATION

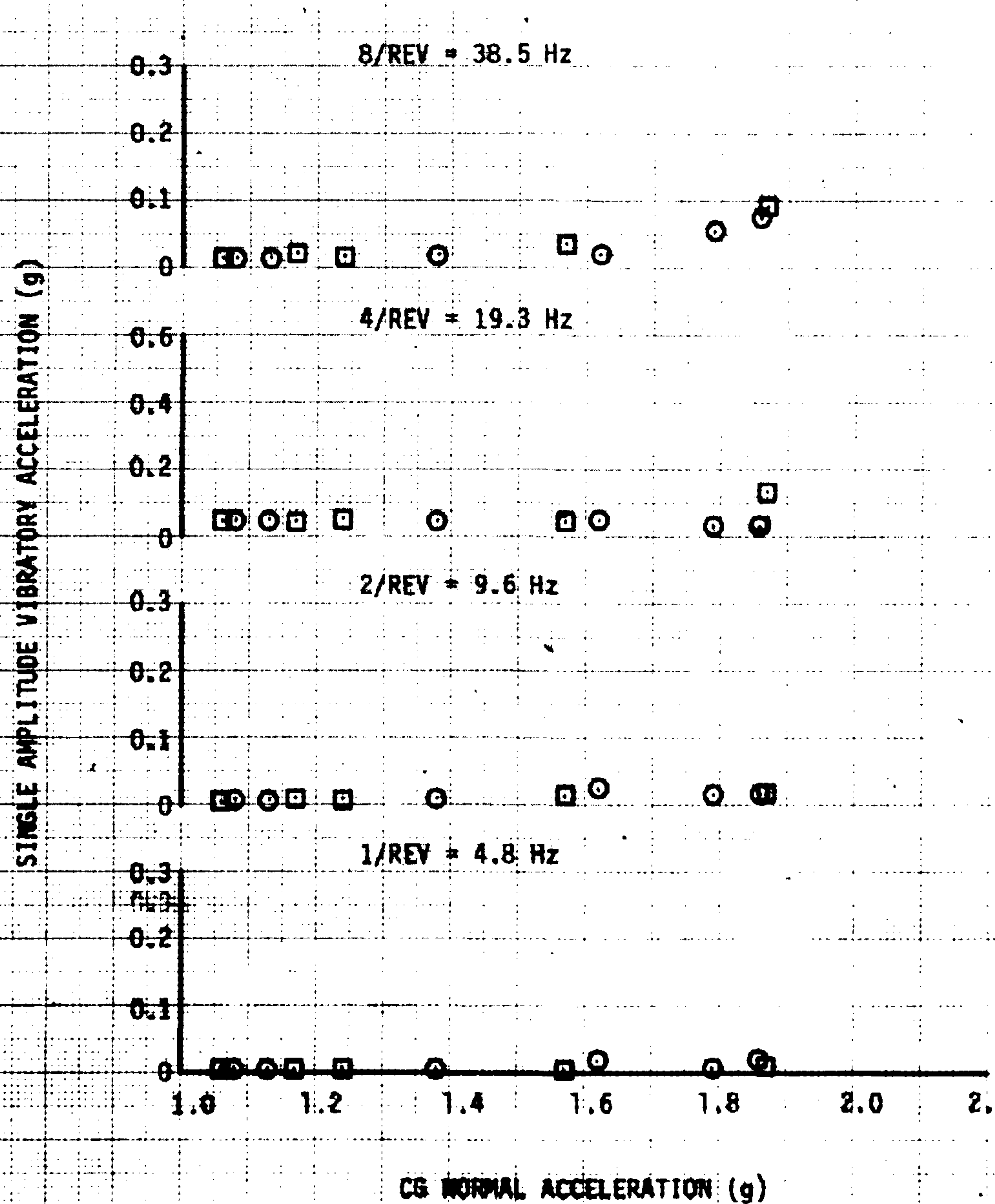


FIGURE 93
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
COPILOT SEAT VERTICAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
○	13920	206.7(AFT)	-0.6 LT	5180	14.5	289	RT TURN	134
□	14120	206.6(AFT)	-0.5 LT	5160	14.5	289	LT TURN	134

NOTE CLEAN CONFIGURATION

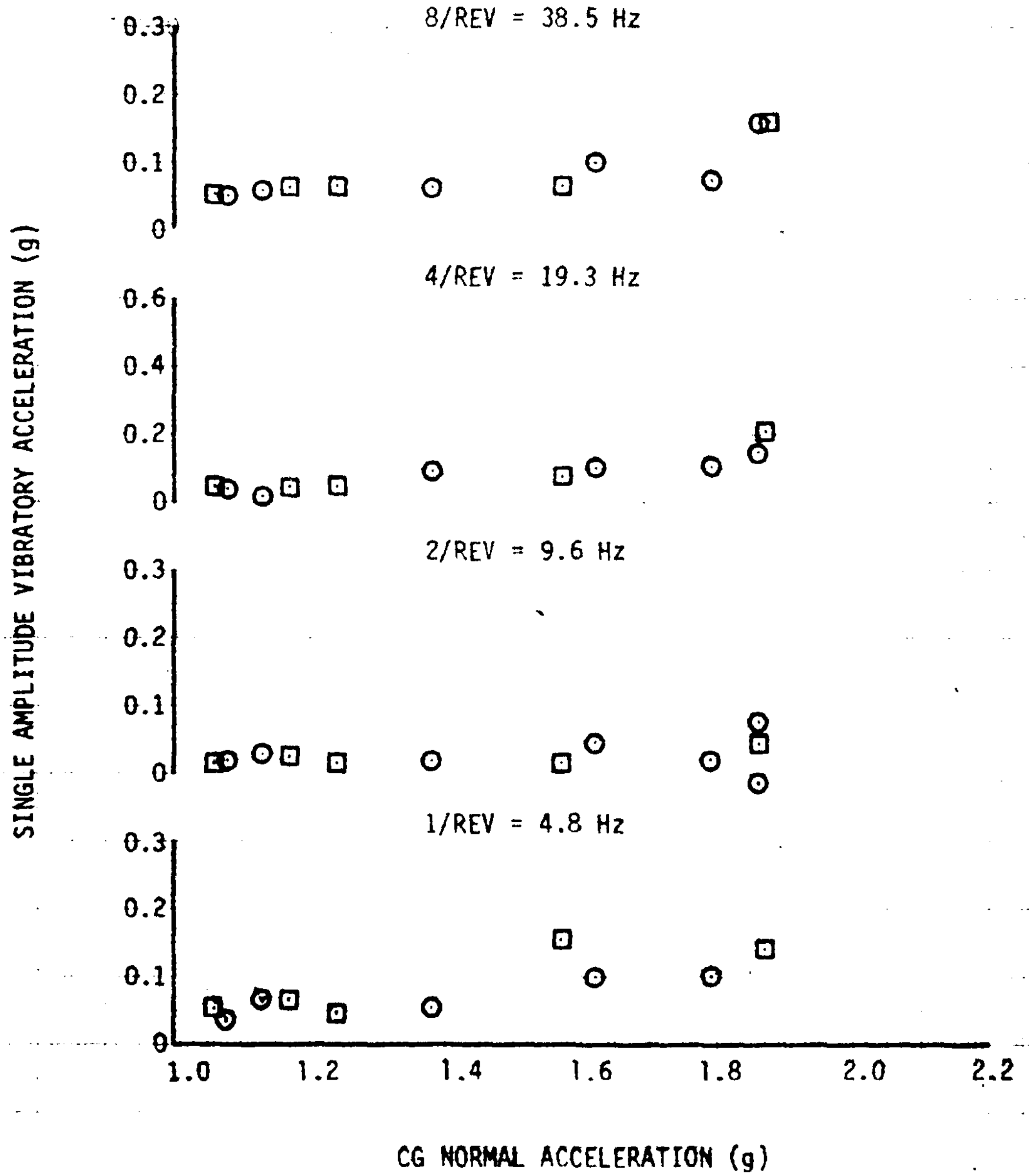


FIGURE 94
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
COPILOT SEAT LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
○	13920	206.7(AFT)	-0.6 LT	5180	14.5	289	RT TURN	134
□	14120	206.6(AFT)	-0.5 LT	5160	14.5	289	LT TURN	134

NOTE: CLEAN CONFIGURATION

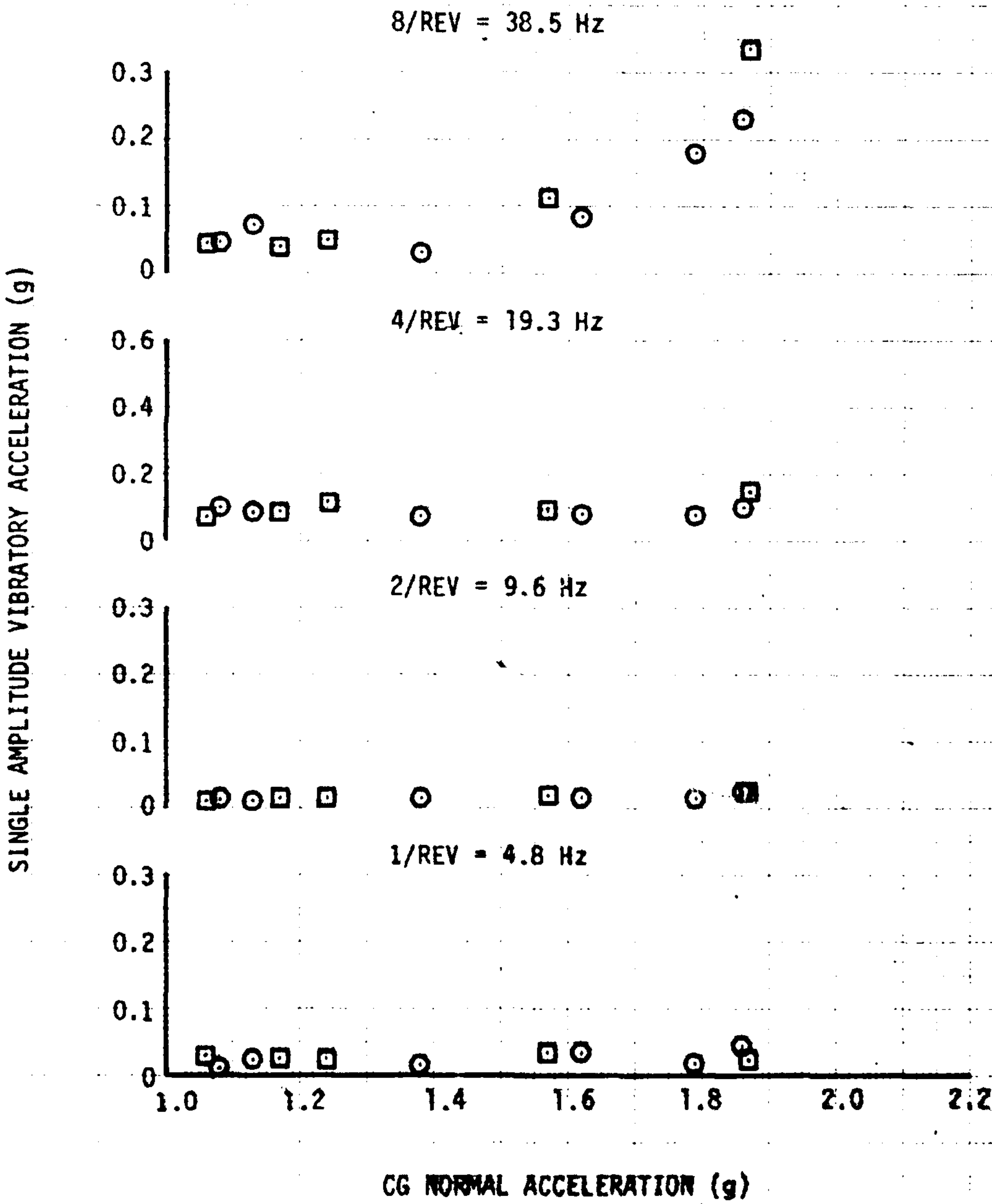


FIGURE 95
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
COPILOT SEAT LONGITUDINAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
O	13920	206.7(AFT)	-0.6 LT	5180	14.5	289	RT TURN	134
□	14120	206.6(AFT)	-0.5 LT	5160	14.5	289	LT TURN	134

NOTE: CLEAN CONFIGURATION

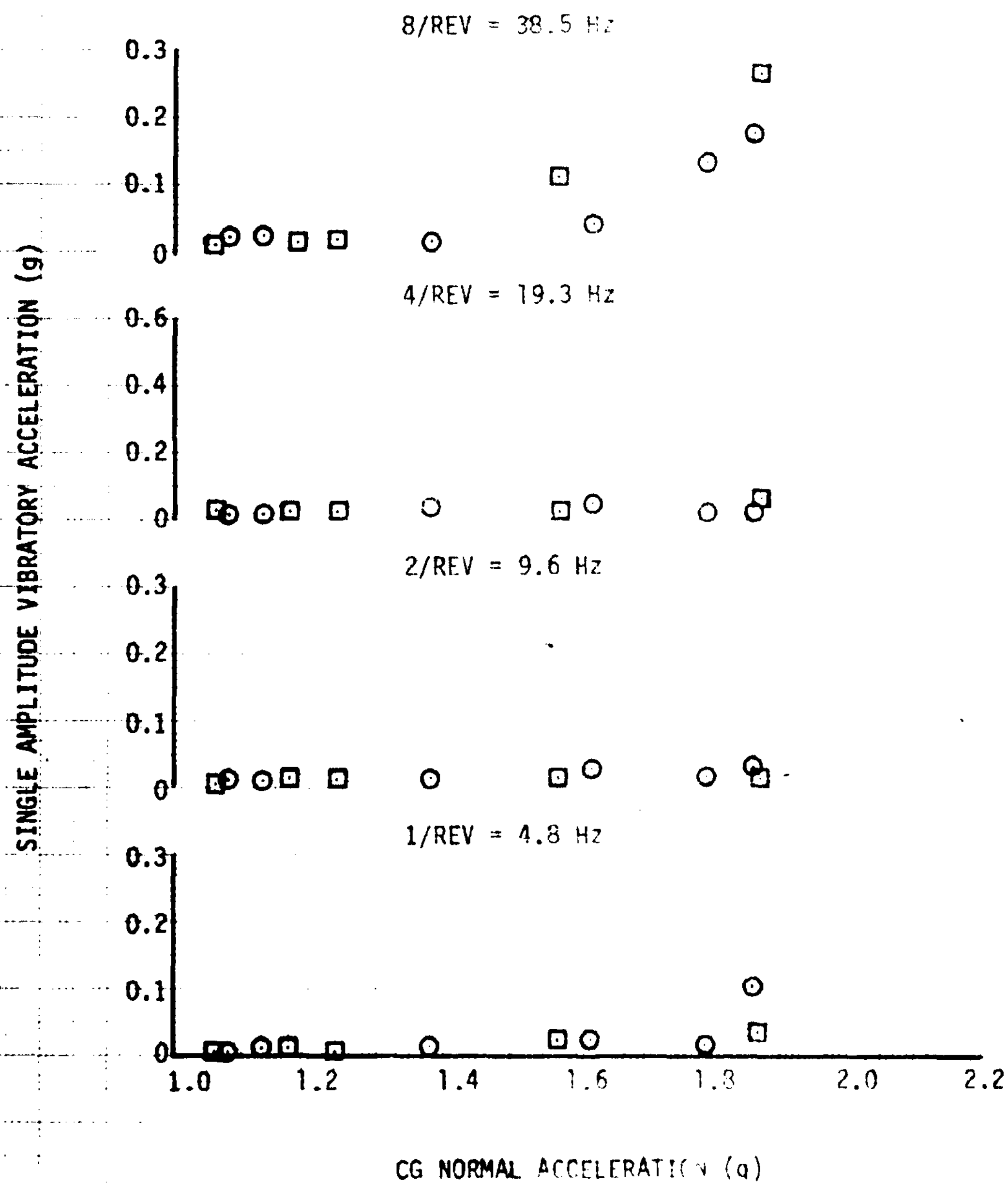


FIGURE 96
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
AIRCRAFT CG VERTICAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
○	13920	206.7(AFT)	-0.6 LT	5180	14.5	289	RT TURN	134
□	14120	206.6(AFT)	-0.5 LT	5160	14.5	289	LT TURN	134

NOTE: CLEAN CONFIGURATION

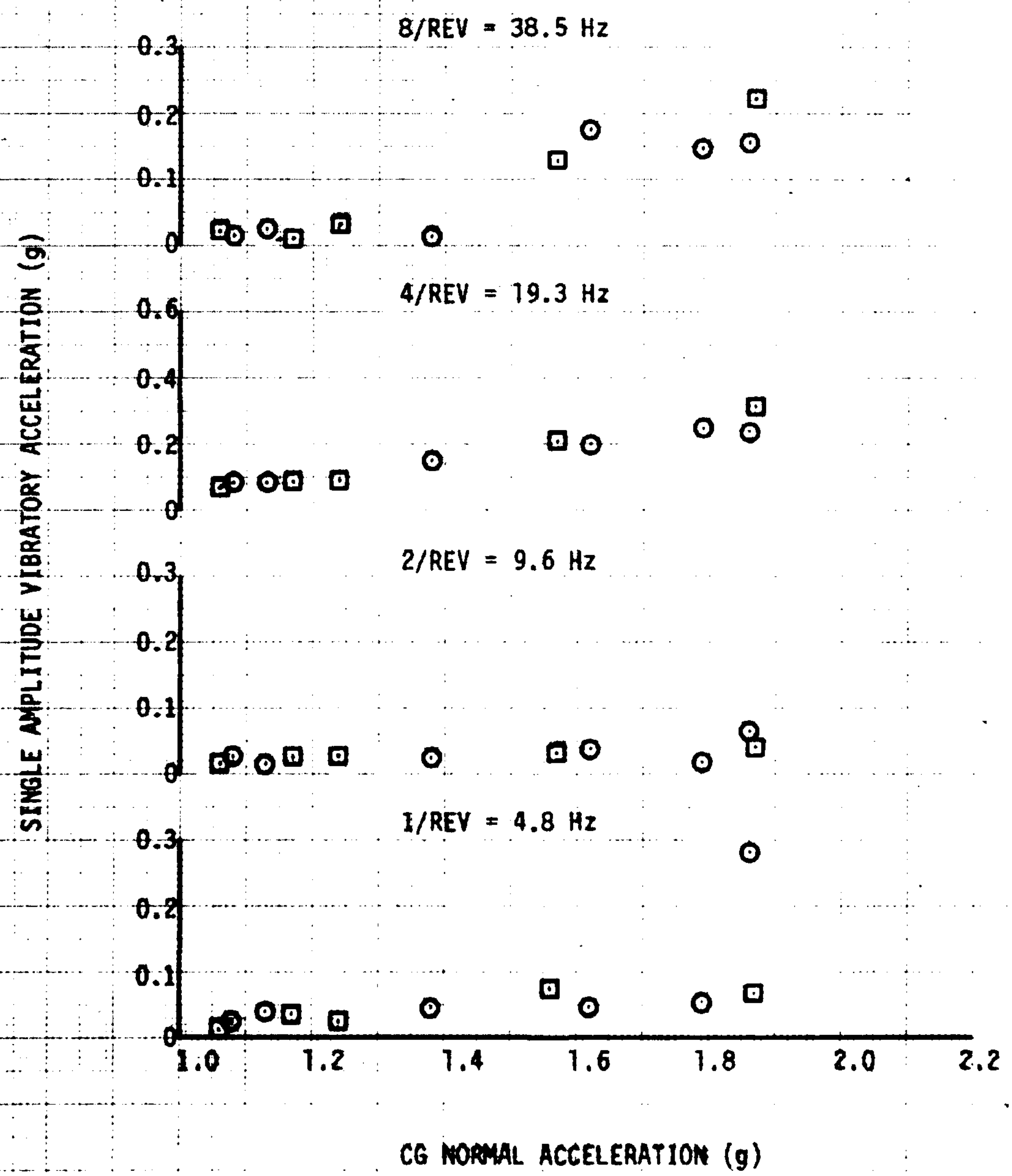


FIGURE 97
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
AIRCRAFT CG LATERAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
○	13920	206.7(AFT)	-0.6 LT	5180	14.5	289	RT TURN	134
□	14120	206.6(AFT)	-0.5 LT	5160	14.5	289	LT TURN	134

NOTE: CLEAN CONFIGURATION

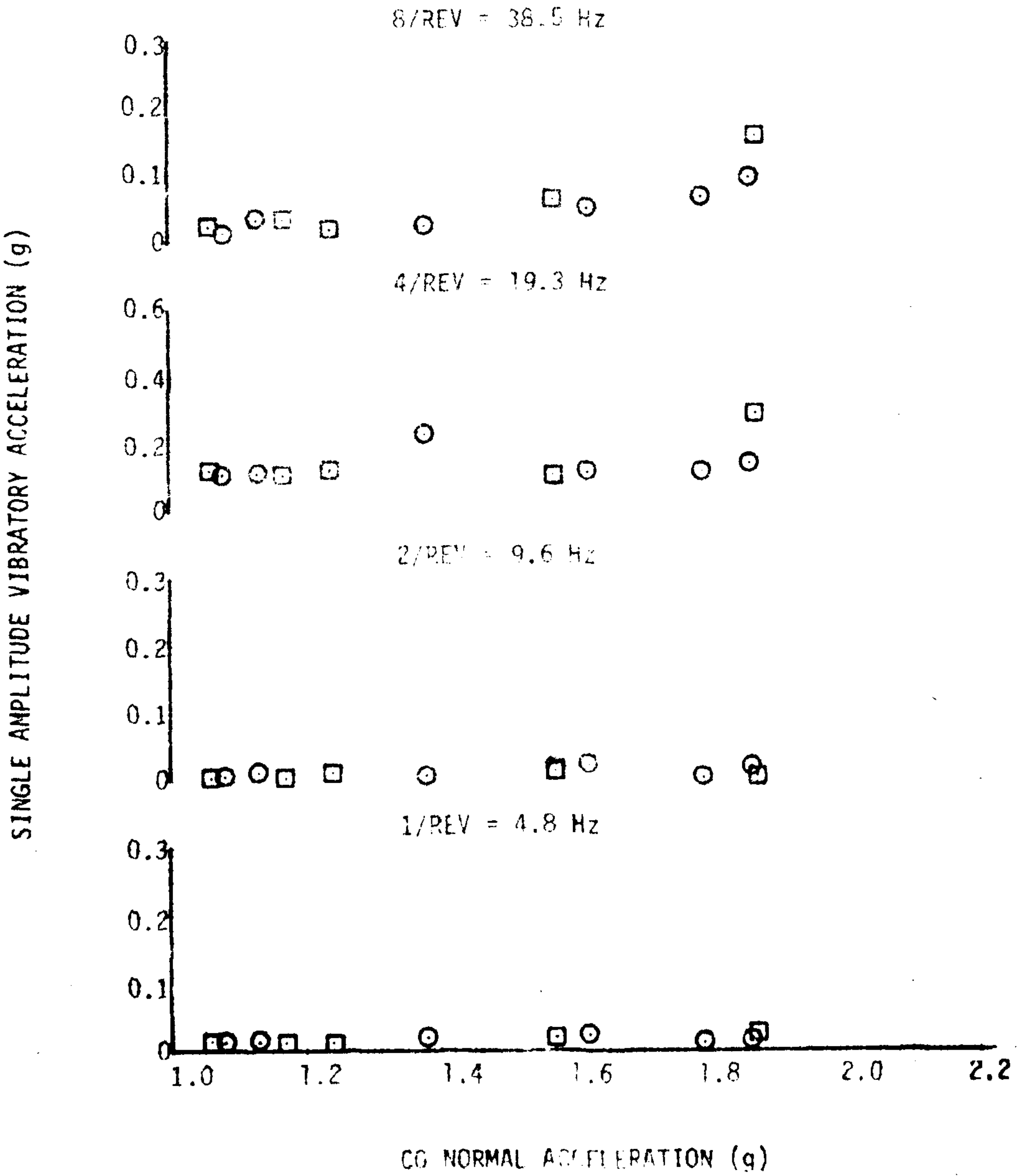


FIGURE 98
VIBRATION CHARACTERISTICS
YAH-64 USA S/N 74-22248
AIRCRAFT CG LONGITUDINAL

SYM	AVG GROSS WEIGHT (LB)	AVG CG LOCATION LONG (FS)	AVG CG LOCATION LAT (BL)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	AVG ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
○	13920	206.7(AFT)	-0.6 LT	5180	14.5	289	RT TURN	134
□	14120	206.6(AFT)	-0.5 LT	5160	14.5	289	LT TURN	134

NOTE: CLEAN CONFIGURATION

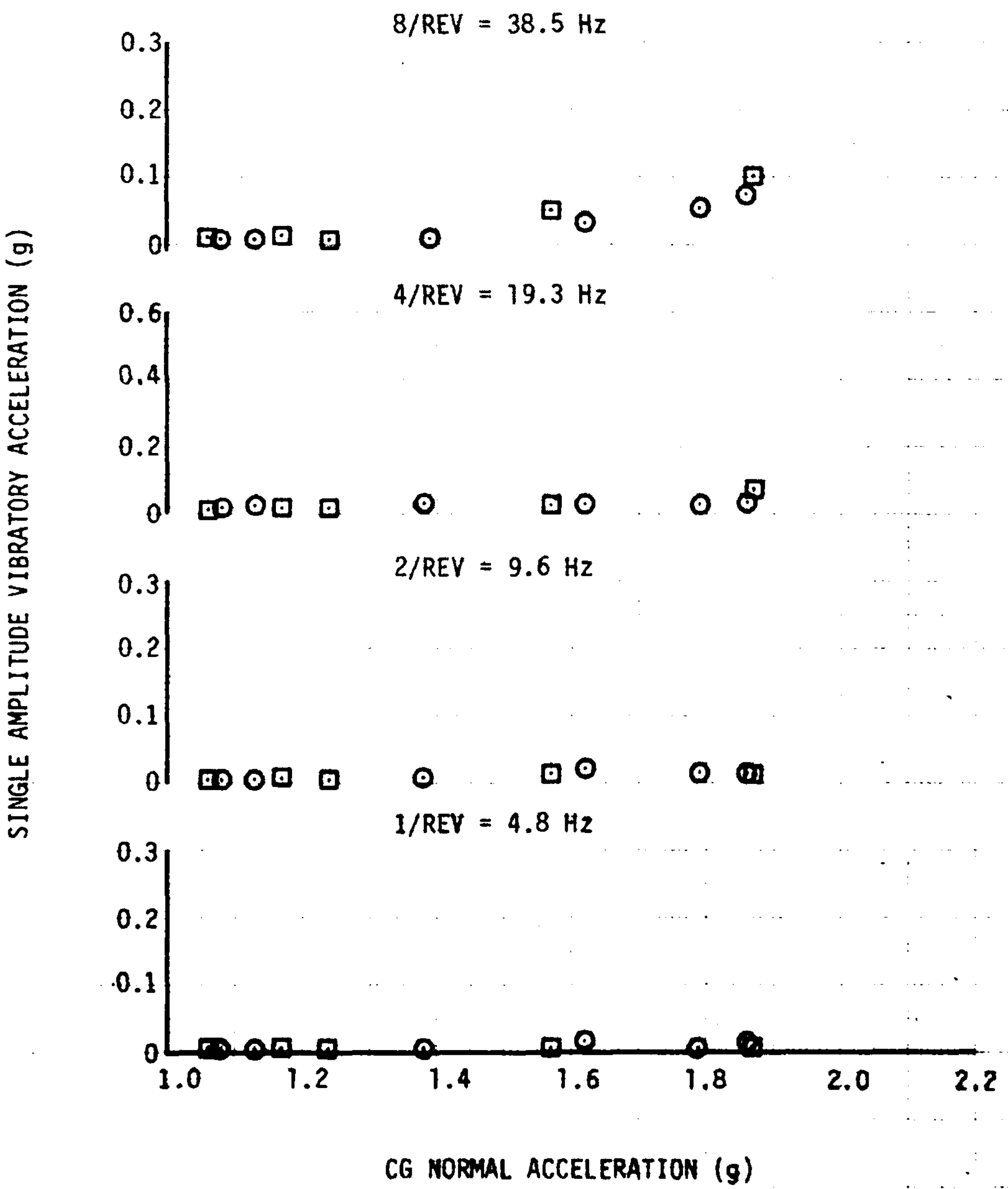


FIGURE 99
VIBRATION SPECTRUM
YAH-64 USA S/N 74-22248
PILOT SEAT VERTICAL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
14650	200.4(FWD)	-0.6 LT	4240	15.0	289	LVL FLIGHT	128

NOTE: 8 HELLFIRE CONFIGURATION

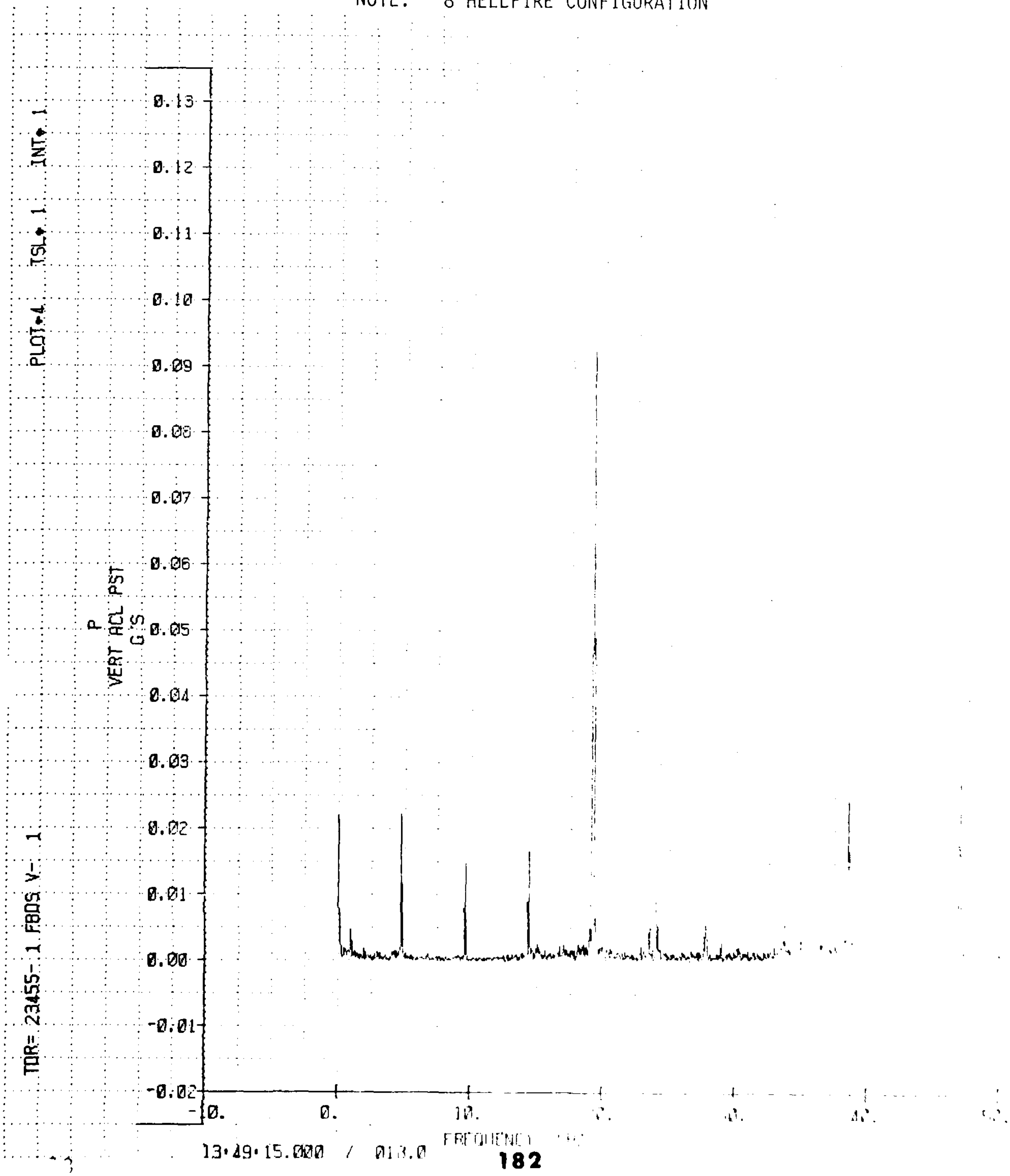


FIGURE 100
VIBRATION SPECTRUM
YAH-64 USA S/N 74-22248
PILOT SEAT LATERAL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
14650	200.4(FWD)	-0.6 LT	4240	15.0	289	LVL FLIGHT	128

NOTE: 8 HELLFIRE CONFIGURATION

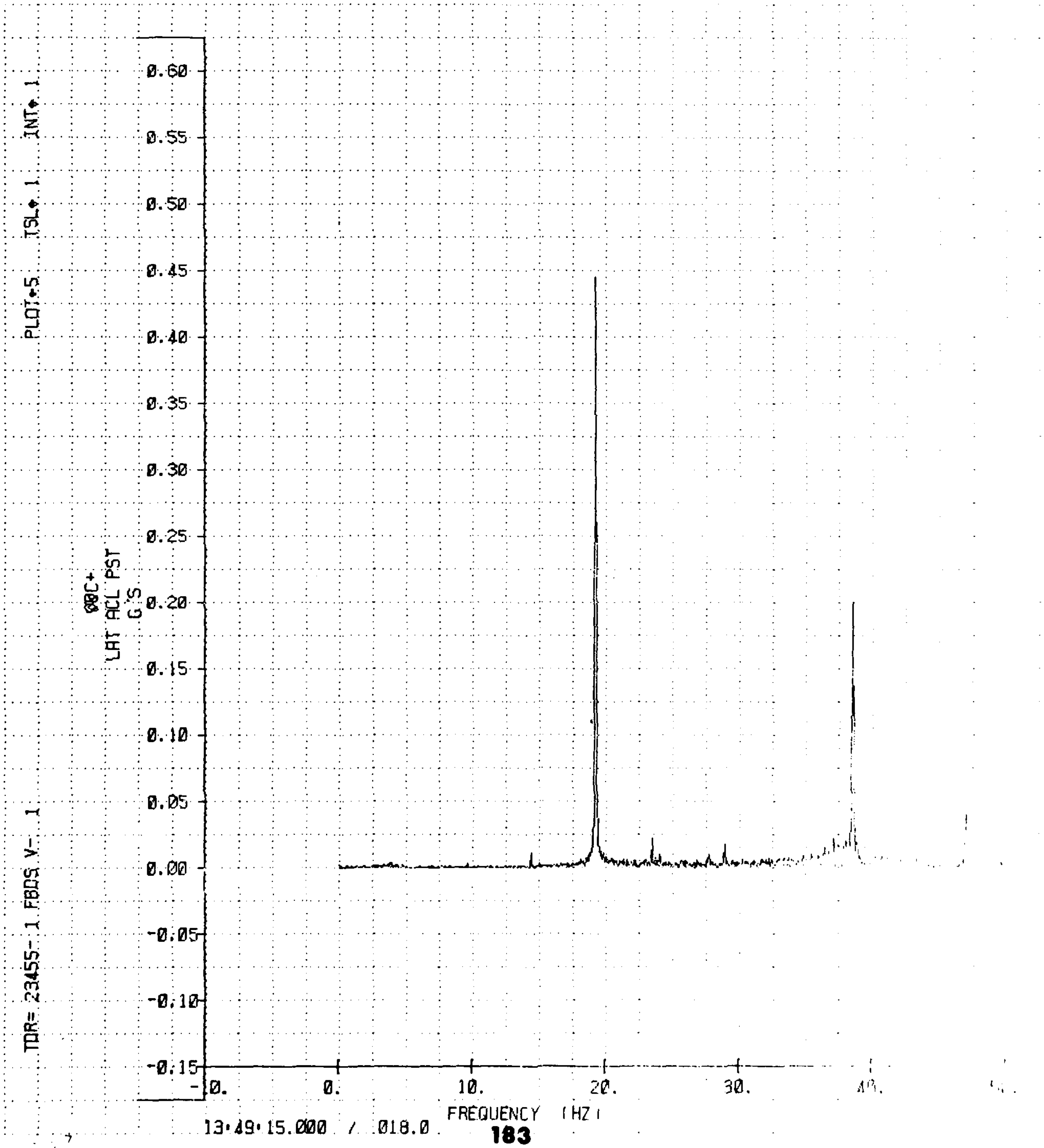


FIGURE 101
VIBRATION SPECTRUM
YAH-64 USA S/N 74-22248
PILOT SEAT LONGITUDINAL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
14650	200.4(FWD)	-0.6 LT	4240	15.0	289	LVL FLIGHT	128

NOTE: 8 HELLFIRE CONFIGURATION

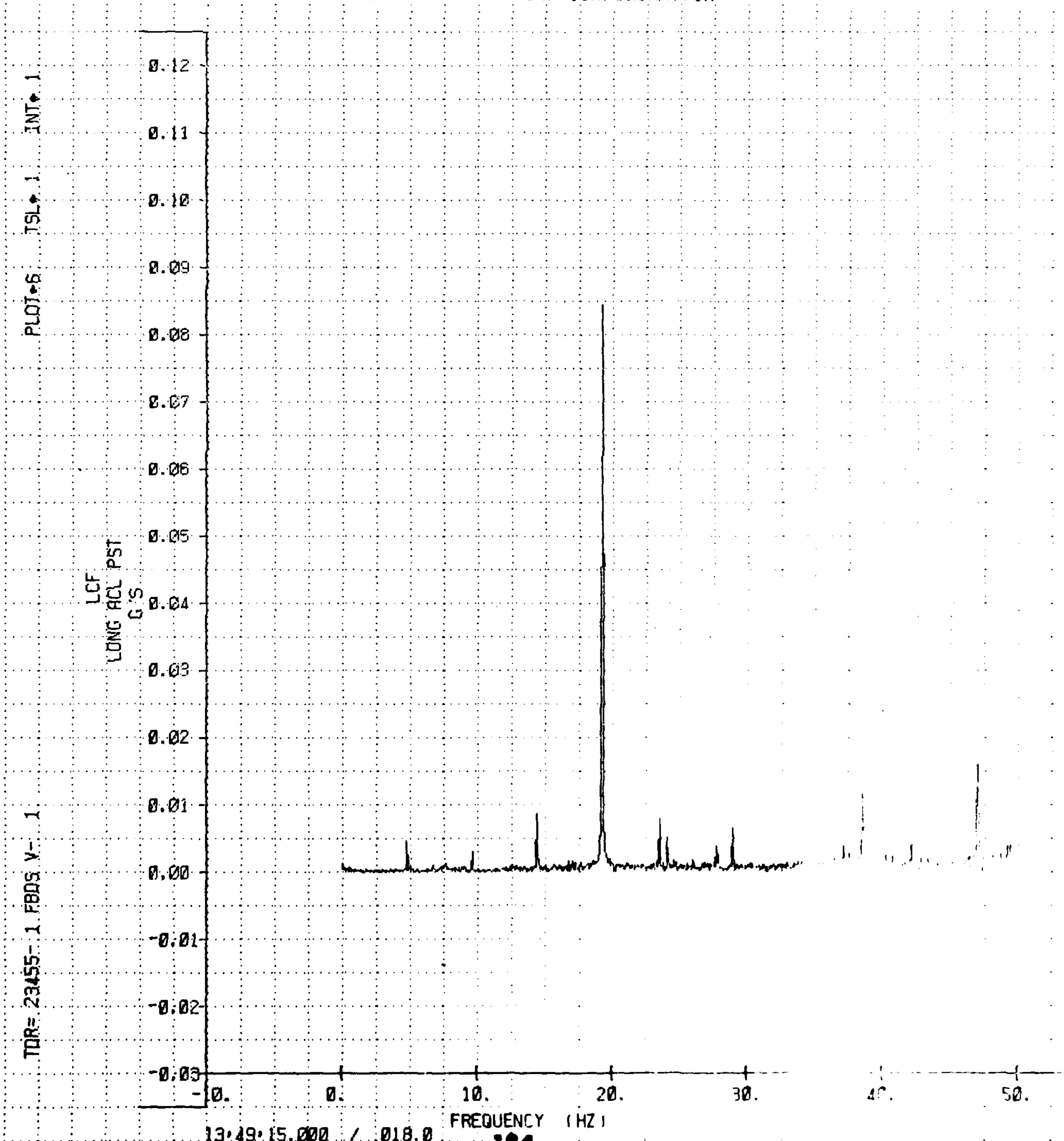


FIGURE 102
VIBRATION SPECTRUM
YAH-64 USA S/N 74-22248
COPILOT SEAT VERTICAL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
14650	200.4(FWD)	-0.6 LT	4240	15.0	289	LVL FLIGHT	128

NOTE: 8 HELLFIRE CONFIGURATION

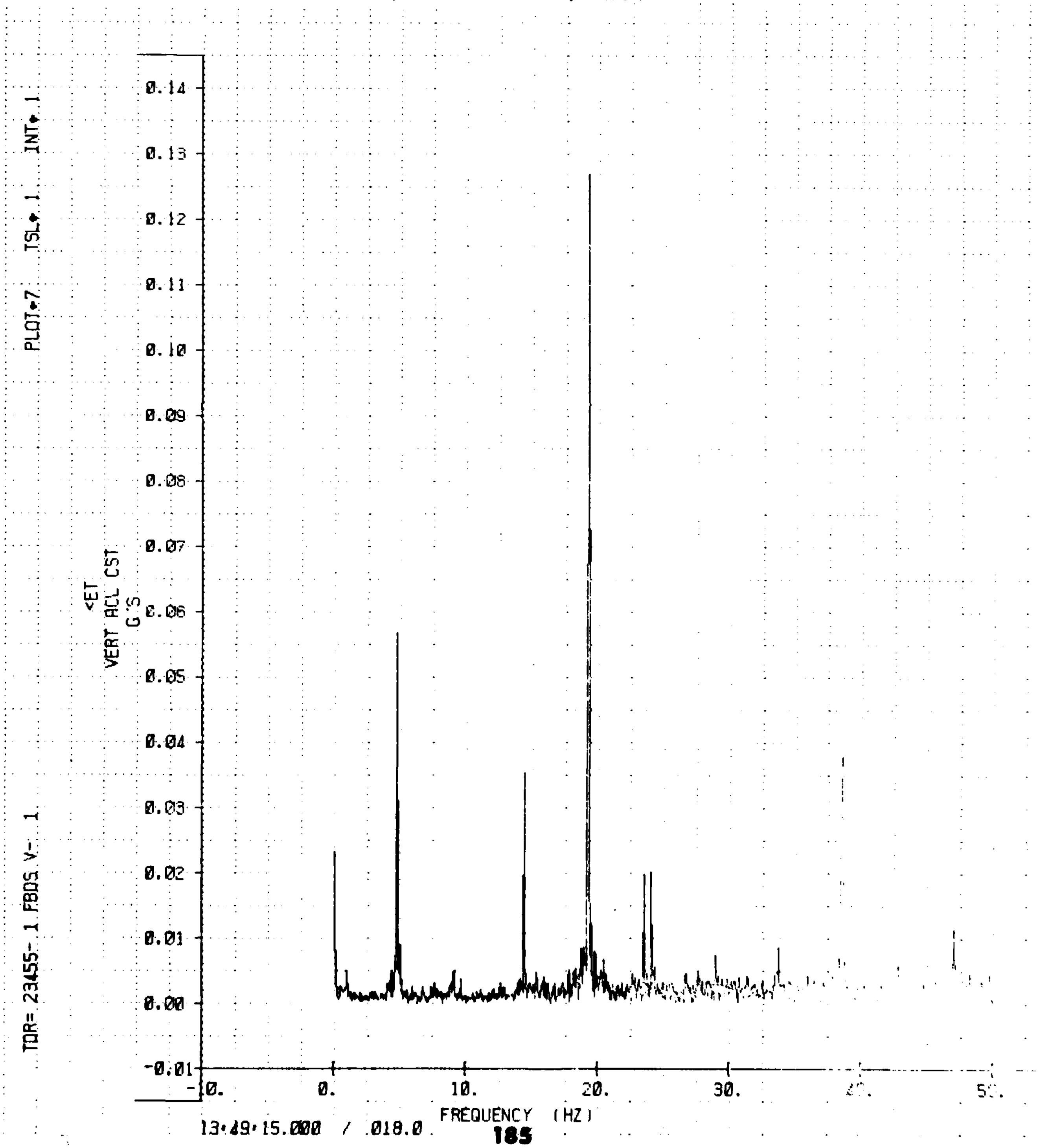


FIGURE 103
VIBRATION SPECTRUM
YAH-64 USA S/N 74-22248
COPILOT SEAT LATERAL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
14650	200.4(FWD)	-0.6 LT	4240	15.0	289	LVL FLIGHT	128

NOTE: 8 HELLFIRE CONFIGURATION

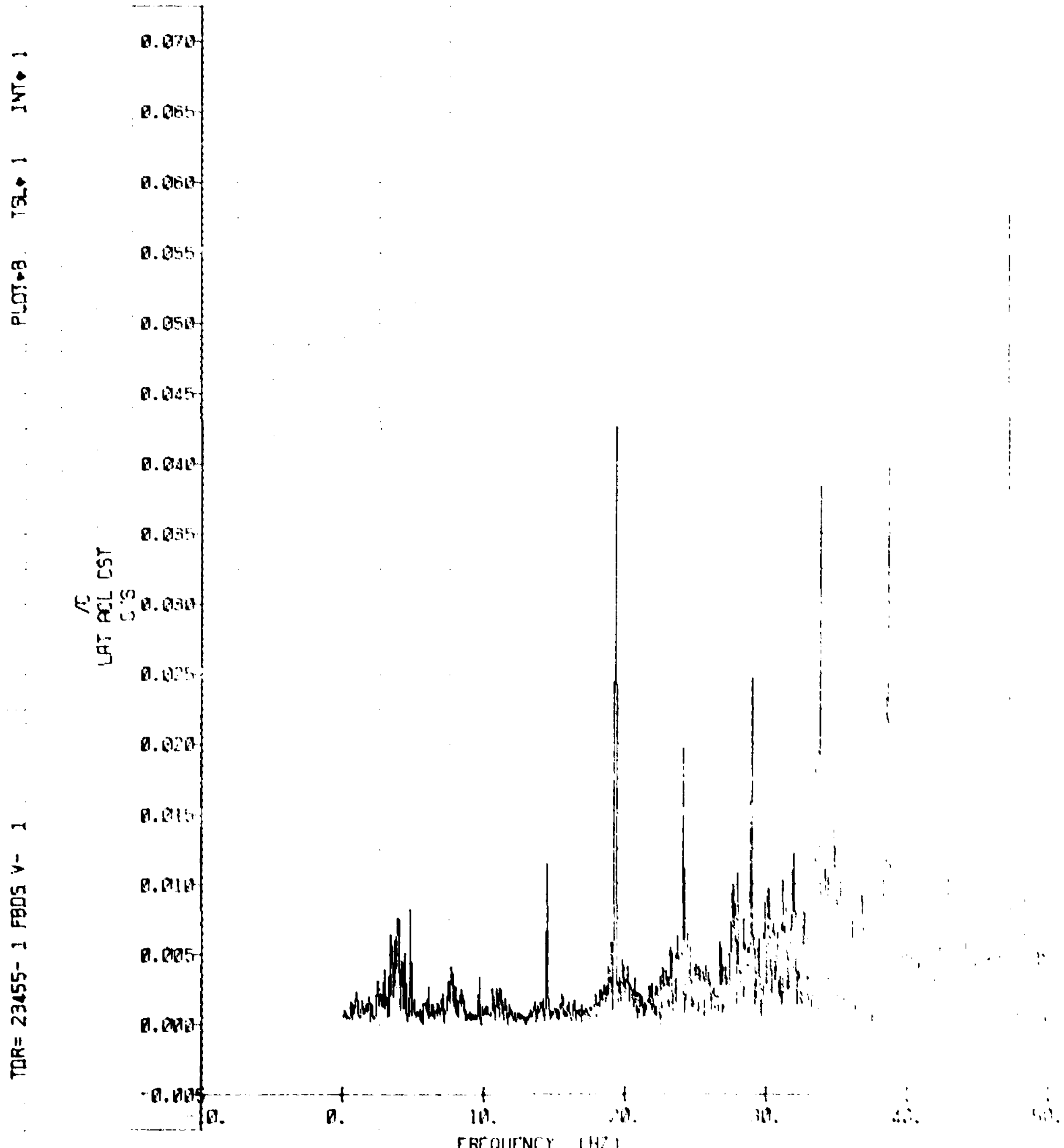


FIGURE 104
VIBRATION SPECTRUM
YAH-64 USA S/N 74-22248
COPILOT SEAT LONGITUDINAL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
14650	200.4(FWD)	-0.6 LT	4240	15.0	289	LVL FLIGHT	128

NOTE: 8 HELLFIRE CONFIGURATION

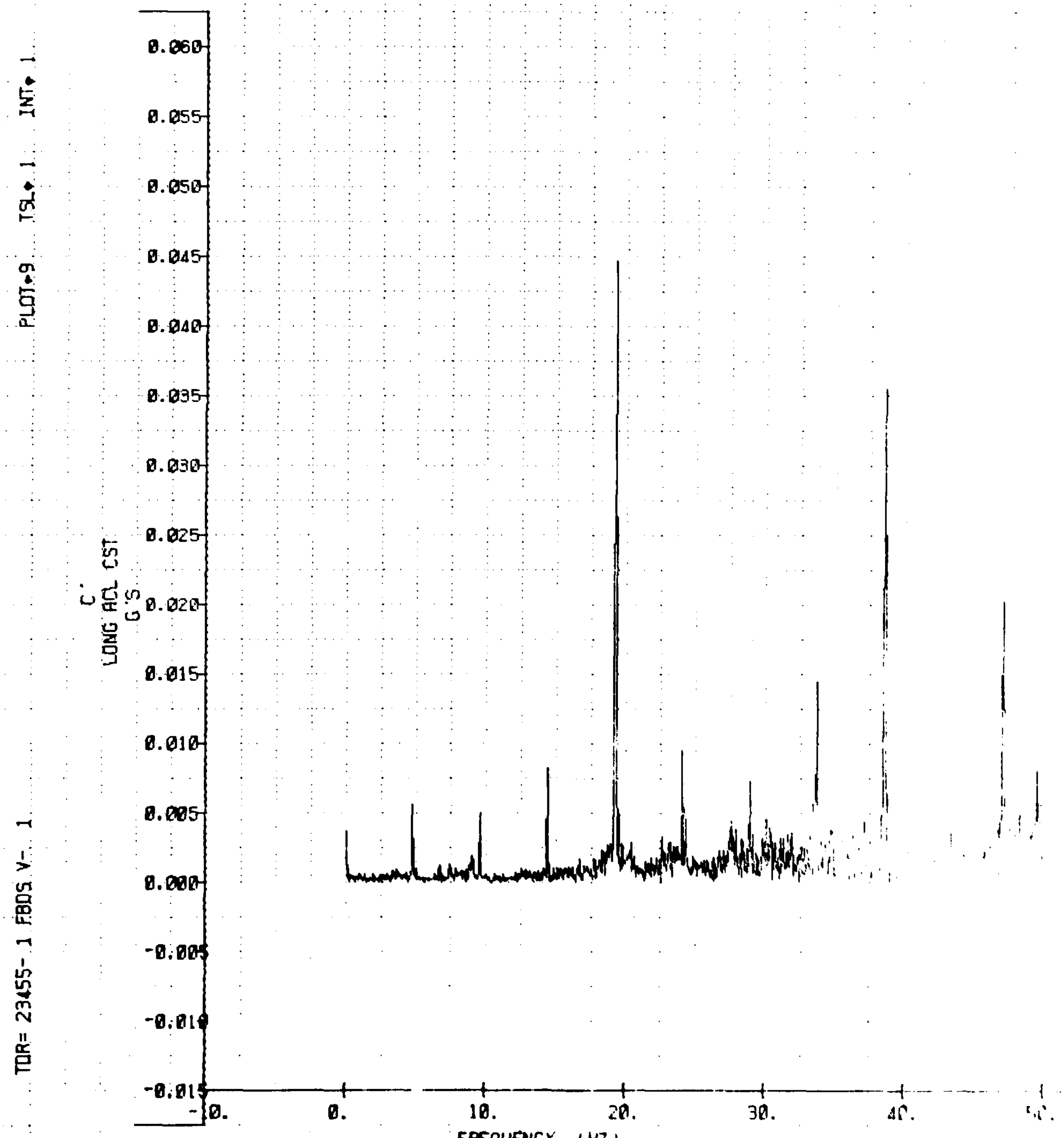


FIGURE 105
VIBRATION SPECTRUM
YAH-64 USA S/N 74-22248
AIRCRAFT CG VERTICAL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
14650	200.4(FWD)	-0.6 LT	4240	15.0	289	LVL FLIGHT	128

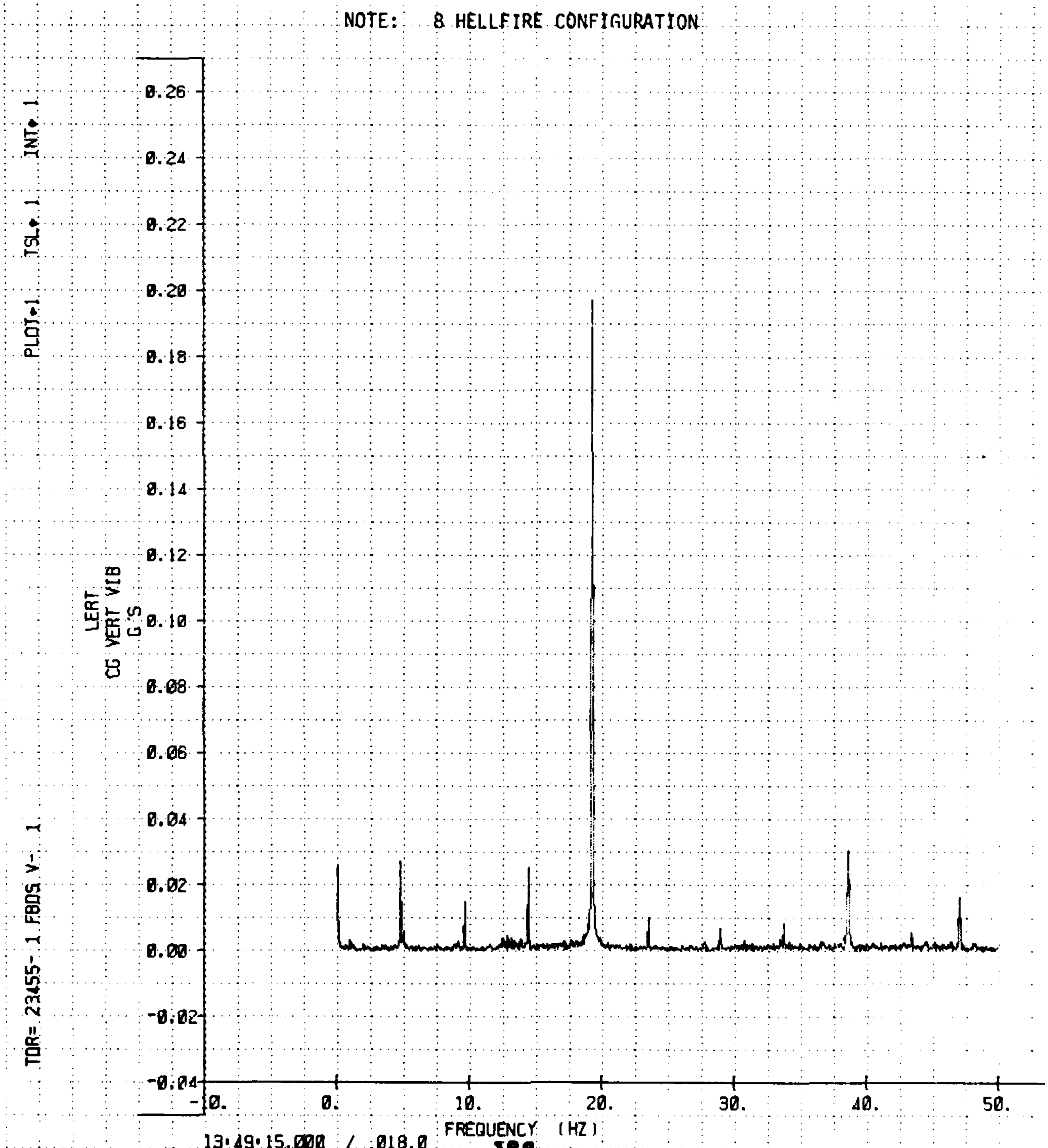


FIGURE 106
VIBRATION SPECTRUM
YAH-64 USA S/N 74-22248
AIRCRAFT CG LATERAL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
14650	200.4(FWD)	-0.6 LT	4240	15.0	289	LVL FLIGHT	128

NOTE: 8 HELLFIRE CONFIGURATION

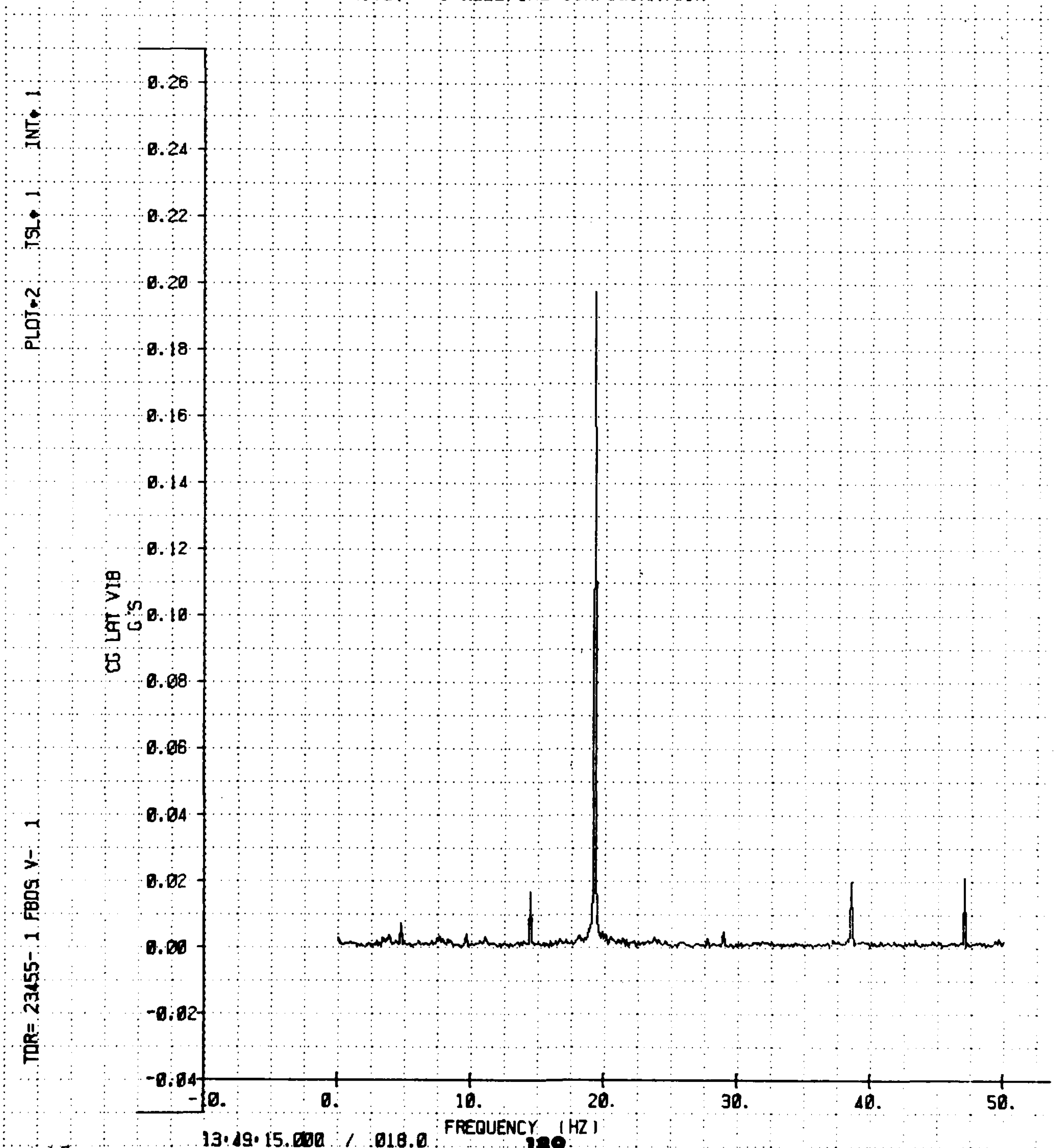
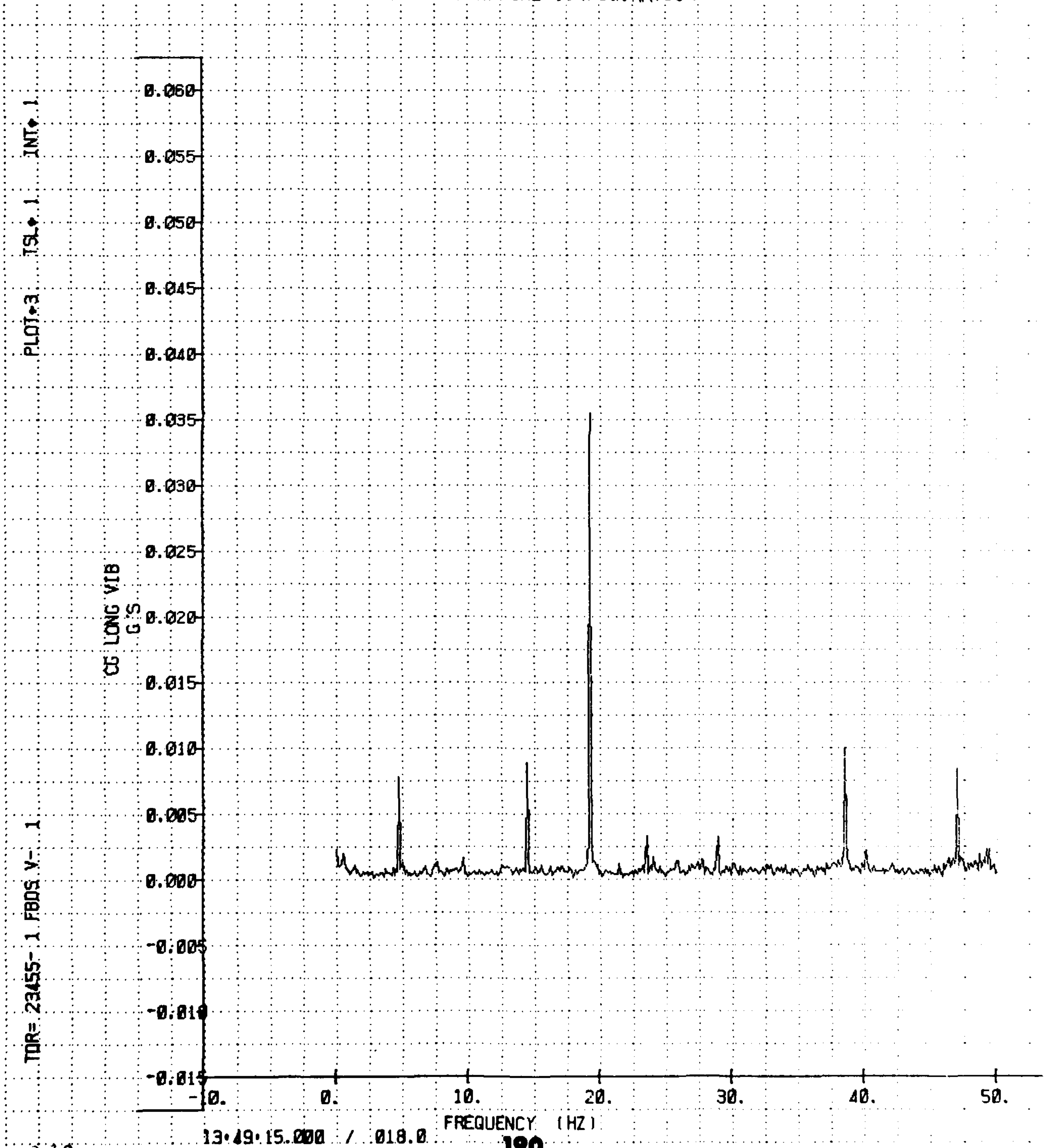


FIGURE 107
VIBRATION SPECTRUM
YAH-64 USA S/N 74-22248
AIRCRAFT CG LONGITUDINAL

GROSS WEIGHT (LB)	CG LOCATION LONG (FS)	CG LOCATION LAT (BL)	DENSITY ALTITUDE (FT)	OAT (°C)	ROTOR SPEED (RPM)	FLIGHT CONDITION	CALIBRATED AIRSPEED (KNOTS)
14650	200.4(FWD)	-0.6 LT	4240	15.0	289	LVL FLIGHT	128

NOTE: 8 HELLFIRE CONFIGURATION



APPENDIX F. GLOSSARY

a	Speed of sound
A	Main rotor disc Area (ft^2)
AAH	Advance Attack Helicopter
app	Appendix
APU	Auxiliary Power Unit
ASE	Automatic Stabilization Equipment
AV-02	Air Vehicle - 02
AV-03	Air Vehicle - 03
AVSCOM	US Army Aviation Systems Command
AVRADCOM	US Army Aviation Research and Development Command
BHO	Black Hole Ocarina
BITE	Built In Test Equipment
BL	Butt Line
BUCS	Back-Up Control System
C	Celsius
CAS	Control Augmentation System
CG	Center of Gravity
C_L	Centerline
C_P	Coefficient of Power
C_T	Coefficient of Thrust
deg	Degree
DT1	Development Test 1
ECL	Engine Condition Levers
ECU	Electrical Control Unit
EDT 1	Engineer Design Test 1
EDT 2	Engineer Design Test 2
EPR	Equipment Performance Report
ETP	Engine Test Procedure
fe	Equivalent flat plate area (ft^2)
FFAR	Folding Fin Aerial Rocket
FFS	Force Feel System
fig.	Figure
FOD	Foreign Object Damage
fs, FS	Fuselage Station
ft	Feet
FTS	Force Trim System
g	Acceleration of gravity
GCA	Ground Controlled Approach
GCT	Government Competitive Test
GPM	Gallons Per Minute
GW	Gross Weight
HH	Hughes Helicopters
HMU	Hydromechanical Unit
Hp	Pressure altitude
HQRS	Handling Qualities Rating Scale
Hz	Hertz
IGE	In Ground Effect
IMC	Instrument Meteorological Conditions

in.	Inches
IRP	Intermediate Rated Power
ITO	Instrument Takeoff
lb	Pound
LVDT	Linear Variable Displacement Transducer
KCAS	Knots Calibrated Airspeed
KIAS	Knots Indicated Airspeed
KTAS	Knots True Airspeed
OGE	Out of Ground Effect
mm	Millimeter
Mod 1	Modification 1
Mod 2	Modification 2
Mod 2B	Modification 2B
M_{tip}	Advancing tip Mach number
N_g	Gas producer speed
NOE	Nap Of the Earth
N_p	Power turbine speed
N_R	Main rotor speed
PCM	Pulse Code Modulation
PSI	Pounds per Square Inch
PSIG	Pounds per Square Inch Gauge
Q	Engine output shaft torque
R	Radius (ft)
ref	Reference
RPM	Revolutions Per Minute
SAS	Stability Augmentation System
sec	Seconds
SHP	Shaft Horsepower
S/N	Serial Number
TGT	Turbine Gas Temperature
$T_{4.5}$	Turbine gas temperature
USAAEFA	US Army Aviation Engineering Flight Activity
V	Velocity
VDC	Volts Direct Current
V_H	Maximum Horizontal Velocity
V_T	True airspeed
VRS	Vibration Rating Scale

Greek and Miscellaneous Symbols

Δ	Incremental change
μ	Advance ratio
ρ	Air density (slugs/ft^3)
Ω	Main rotor angular velocity (radians/sec)
$\sim$	Approximately
4/rev	4th harmonic of the main rotor

APPENDIX G. EQUIPMENT PERFORMANCE REPORTS

The following EPR's were submitted during this test:

EPR No.	Date	Descriptive Title
78-23-01	20 June 79	Rotor Brake Slippage
78-23-02	20 June 79	Lack of airframe fuel filter
78-23-03	20 June 79	Difficulty in rigging wing flaps
78-23-04	20 June 79	Bypassing automatic refueling safety systems
78-23-05	20 June 79	Damage to tail wheel support assembly

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